PUNCHES AND DIES

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LAYOUT, CONSTRUCTION AND USE

BY

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PREFACE

This book has been written with the object of placing before die-makers, tool-makers and tool draftsmen, certain definite information not heretofore available as a whole, although some of the material here published is necessarily of a fundamental character with which all mechanics must familiarize themselves in their progress toward a reasonably complete knowledge of the subject of press tools and their construction.

Practically ninety per cent of the material in these pages has been gathered and prepared expressly for this volume and is here published for the first time. The remainder has been selected from current articles originally published by the author and by other contributors to the technical press. For information taken from the latter sources full credit is given under the list of references at the back of the volume.

In gathering photographs, drawings and data for the preparation of this book the author has been accorded free access to the methods and practice of many of the leading plants of America where he has received the hearty coöperation and assistance of numerous shop executives, tool room foremen, press room foremen, die-makers and others, and full appreciation of this invaluable aid is herewith expressed. In this connection especial thanks are due the following firms and individuals:

Marchant Calculating Machine Co., E. W. Bliss Co., Smith Premier Typewriter Co., Noiseless Typewriter Co., Westinghouse Electric and Manufacturing Co., Waltham Machine Works, B. C. Ames Co., Henry Disston Sons Co., Aluminum Products Co., American Coin Register Co., Holt Manufacturing Co., Gilro Machine Co., A. H. Marchant, W. Nonamaker, F. B. Shear, A. L. Howes, J. A. Ruffin, W. P. Smith, F. E. Ross, A. B. Swift, H. C. Lockey.

THE AUTHOR.

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CHAPTER I

PRESS TOOLS IN GENERAL

The class of shop equipment commonly known as press tools or punches and dies, is becoming extended into so many lines of manufacture and in those lines assuming such constantly increasing aspects of importance, that no one responsible for factory output or in any way connected with design, manufacture, or tool department activities can afford at the present time to remain uninformed in respect to the details of construction and application of these tools if the product of the plant is of such character as to admit of the utilization of sheet metal working apparatus. And, it may be added, there are to-day very few lines of metal manufacture where such tools cannot be employed to advantage, even though in many instances their complete possibilities are not recognized and appreciated until a detailed study has been made of existing methods in the plant, and a comparative analysis drawn up to determine what parts may be converted with economy into press manufactured material.

More and more it has come to be the practice to produce, by some form of stamping process, work that formerly was almost invariably manufactured from the solid bar, from forgings, or from some other class of solid material. So, in addition to a widely diversified line of products that have always been recognized as press work pure and simple, there have developed numerous other classes of metal parts whose manufacture has been transformed from the conventional operations of, say, turning, drilling, and so on, to the processes available under press working methods. It therefore is quite within the truth to state that the time is already here when no progressive individual connected with metal parts production, whether in drawing office or shop departments, can consistently refrain from persistent investigation of current practice in press working operations, which, though often fundamental in character, display in details of application distinct advance over the methods of the past, with corresponding progress as measured by quality and volume of output.

Extension of Press Uses

Where formerly it was the occasional or the specialized shop that made use of press working methods, at the present time it is the exception to find a well organized plant engaged in small or medium parts production that does not find it necessary to utilize metal working presses to a considerable extent. Even where very large articles are produced from sheet metal an important percentage of the work and frequently the whole of it is accomplished by the blanking, drawing, forming, and other processes of the press department.

As a natural consequence, the rather unusual occupation of the die maker of early times is to-day followed by a great number of tool makers who have entered upon this highly skilled branch of shop work and whose handicraft is to be noted in tool rooms innumerable throughout the country. Similarly, the tool designers over the drawing boards in our plants are devoting more and more attention to the consideration of progressive methods of handling sheet metal through dies of various classes, and these men, like those in the tool room, exhibit an increasing degree of interest in the general subject of press tools.

Owing to the fact that punch press operations are peculiar to themselves, and the tools of this branch quite incomparable with other special apparatus about the shop, any book treating upon the general subject forming the title of the present volume must necessarily deal to a certain extent with some few details of a fundamental character; details possibly of common knowledge to such tool makers and draftsmen as have long specialized upon work of this nature, but none the less important however to men who, with perhaps many years of experience in other skilled branches of the machine industry, have had limited opportunity for following the advance gained in the punch and die makers' art. Still, from their ranks must come many of the die makers of the immediate future and therefore in this book, along with examples of what leading mechanics consider their best practice in press tool work, a little space will be devoted to certain elementary considerations.

General Classes of Dies

First, when we speak of dies, we mean just as when we refer to press tools, both punches and dies. Often we mention a set of dies, meaning usually, as before, a punch and a die. While ordinarily the die is secured to the bed of the press or to the bolster thereon, and the punch carried above by the traveling ram or slide of the press, this arrangement is by no means universal, for in many instances marked advantages of operation are derived by inverting the usual order and placing the punch below and mounting the die upon the slide above. And in compound dies, as they are

Fig. 1. — Punch and die cabinet in a modern shop

Class III, which covers various forms of Bending and Forming Dies, may also include, under certain circumstances, Curling and Wiring Dies. That is, when the operations of curling, or of curling and wiring combined, are applied in the manufacture of flat parts whose ends or edges are curled or rolled up, the process is one closely akin to forming as conducted with dies having side closing members which catch the edges of the blank and turn or curl it over as desired.

Where Curling or Wiring operations are applied to such articles as are drawn up to cylindrical or conical form, as in the cases of cups, utensils, or other objects requiring curling around the open end, the Curling and Wiring tools come within Class II as the processes are those involving stretching and drawing over of the annular surface about the mouth of the work.

Class IV comprises Swaging, Heading, Riveting, Staking, Embossing, Coining, Extruding Dies.

Then there are miscellaneous tools that according to individual circumstances may or may not be grouped under some one or other of the above heads: These include Flattening or Straightening Dies, Marking or Numbering Dies, Staking Dies, Crimping Dies, Burnishing or Sizing Dies, Assembling Dies, etc.

Varying Arrangement of Tools

All of the dies in the different groups are made in great variety and in many instances they are combined one with another so that oftentimes one set of tools may incorporate in its construction, two, three, or four distinct classes of dies for performing as many individual operations upon the work at a single pass through the press. Such tools are variously known as Progressive Dies, Follow Dies, Cut-and-Carry Dies, Step-Along Dies, Multi-Stage Dies, Tandem Dies, and so on; in any event the term applied indicates the system of passing the work along through successive stages in the one set of tools. A set of progressive, piercing, and blanking dies with bolster and work will be seen in Fig. 4.

Also, the different types of tools such as blanking dies, piercing dies, etc., are frequently made to blank out several pieces at once or to punch a series of holes at one stroke of the press, such tools then being designed as Gang or Multiple Dies and Gang or Multiple Punches. In the case of the latter where a considerable number of very small holes are pierced at once, the tools are commonly known as Perforating Dies.

Now, with nearly all of the types of tools grouped under the foregoing definite classes, there is a distinction based upon general relationship between punch and die, that is, upon the method of construction whereby alinement is secured between the two members in any given set of tools. This may be briefly referred to at this point and considered more in detail in another chapter.

Fig. 1. — Punch and die cabinet in a modern shop

called, we have before us a common example of a set of press tools in which the die proper carries also a punch: while the opposite tool, the punch proper, carries a die inside. So in neither case of upper or lower tool in the set, considered as a whole, can one be distinguished entirely as a die and the other as a punch for each half combines the functions of both punch and die.

However, no matter what the relative positions of the punch and die may be or how the two tools may be arranged, we may safely define the die as the tool that establishes the external form of the work or of the opening in a pierced piece, and the punch as the corresponding internal member.

In considering press tools as a whole it is of value to note how they fall into certain classes as distinguished by the character of their action upon the metal which is manipulated in their operation. It should be understood here that although reference is distinctly made to metal, numerous other materials are worked by identically the same processes as the various sheet metals such as iron, steel, brass, copper, aluminum, german silver, tin, zinc, etc. These other materials would include such as hard fiber, rubber, card board, leather, paper, mica, fabrics, and so on. Not but what special modifications must be made in many instances where press tools are applied to manufacture of parts from these substances, but in their principal characteristics the tools used are identical with or quite similar to those employed on sheet metal operations, many examples of which are seen in Fig. 1.

How Tools May Be Classified

If now we group the various forms of press tools according to their action upon materials, we shall find that in general they may be classified under four heads as follows:

I. Tools that operate by cutting or "shearing" the metal, for example, blanking dies (Figs. 2 and 3), shearing or cutoff dies, notching dies, etc.

II. Tools that shape the article by drawing the material, causing it to "flow" under tension as in the instances of cupping dies, drawing dies, bulging dies, and so on.

III. Tools that manipulate the stock or the blank already cut out, by some form of bending process. In this class come simple and compound bending dies, forming dies, and the like.

IV. Tools that by compressing, squeezing, or forcing the material cause it to "flow" into the desired form as when acted upon by swaging dies, extruding dies, coining dies, etc.

In Class I may be included the following tools: Blanking, Piercing, Shaving, Notching, Shearing, and Trimming Dies. Also Hollow Cutting or "Dinking" dies, so called, belong in this general class, although made

not for working metal, but rather for cutting out leather, card board, fabrics, and other materials either by hand or machine processes.

Class II includes Cupping, Drawing, Redrawing, Bulging, and Reducing Dies. Strictly speaking the latter tools do not draw or "stretch"

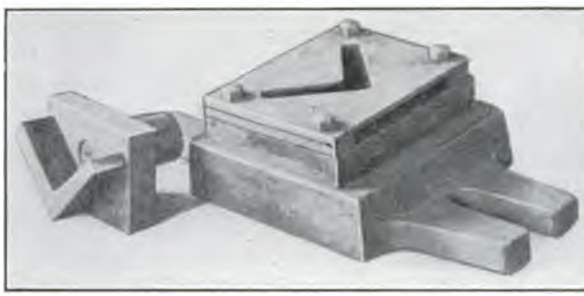


FIG. 2. — Blanking punch and die "open" type

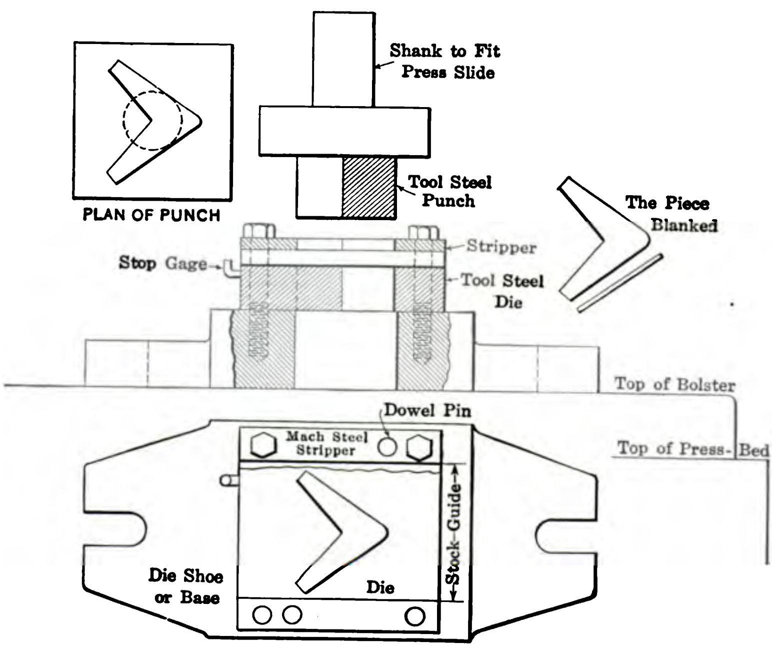


FIG. 3. — Detail of open punch and die

the metal, but rather act in an opposite manner to close or taper a shell, say, already drawn out to required length and body size. Their operation is thus so closely allied to that of drawing and their design so similar that they may be grouped in the same class as the usual drawing die.

bend the end of the sheet metal down a trifle as indicated at *B*, before the cut can start. If, however, we bevel the face of the punch from front to back as at *C*, giving its cutting edge a decided degree of shear, we can see at once that the sheet metal will be readily severed by this very shearing action of the punch edge past the die edges.

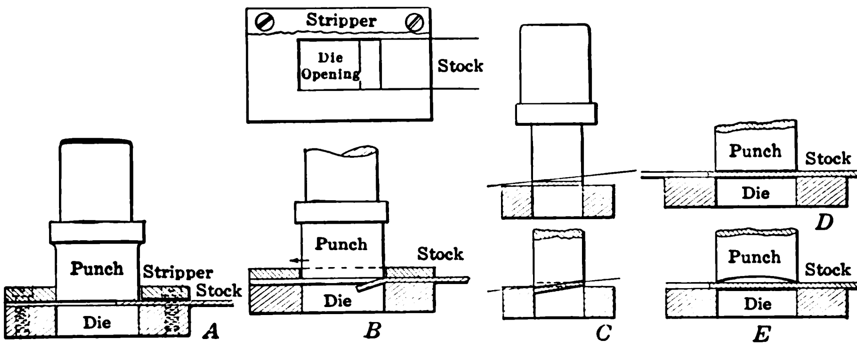


FIG. 7. — Action of punch and die on the stock

And, sometimes this device is resorted to, by the die maker, where certain conditions obtain, although with blanking operations this feature of cutting along one edge only does not of course ordinarily enter in. It is referred to here merely for the purpose of illustrating the general effect resulting from an ordinary flat ended punch striking at one edge only on heavy gage material. In practice the end of the punch comes down squarely as at *D*, cutting out the blank clean and sharp as the punch edges pass down to the die. With heavy stock, the die maker sometimes facilitates matters, as mentioned above, by providing true shearing action on the part of the punch from one end to the other, or as at *E*, where the end of the latter is slightly concaved. Sometimes the die itself is sheared instead of the punch. This device is more common however on piercing punches where heavy plate is punched, the edge of the tool in that case being often made with a spiral contour which shears through the work in a relatively gradual manner.

FIG. 8. — Simple piercing dies

PIERCING TOOLS

Both plain flat-ended and spiral-cutting piercing punches of this nature are illustrated in Figs. 8 and 9 respectively. The type of die shown in Fig. 9 is generally known as a punch die — sometimes as a button die.

Such tools are often made with very small punches which are supported at their cutting ends by passing through a guide plate provided with holes in which the punches are a close fit. Also radial or side closing punches are made for piercing work through the side. While we are apt to think of piercing dies as used principally for round holes, they are almost as frequently employed for making other shapes of openings, square, oblong, irregular, curved, slotted, etc. Thus the dies that cut out the narrow curved cam slot in the disk, Fig. 10, are piercing tools just as definitely as though they were adapted for making a single round hole in the center of the blank or a series of small holes through any part of the object.

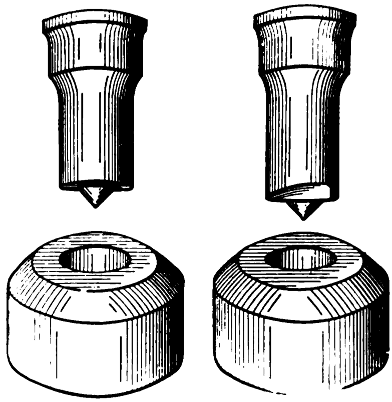


FIG. 9. — Plain and spiral types of punch dies

This set of tools, it will be noticed, are of the subpressed type, or pillar construction, referred to on a preceding page, the punch and die being held

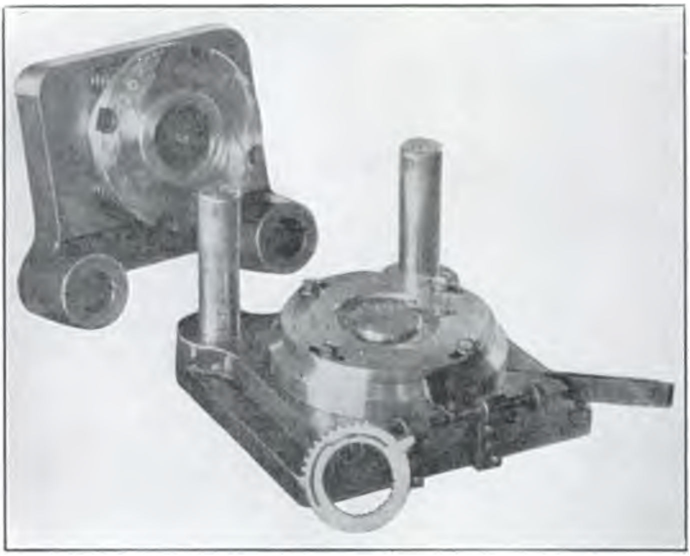


FIG. 10. — Dies for piercing a curved slot

in definite alinement by the upright posts fixed in the die base and forming guides for the punch block in its up and down travel. There are other important features of these tools that will be described at another point in this volume.

Notching and Comb Dies

Notching Dies that cut out a series of straight or tapered openings in a blank as in Fig. 11, are other forms of piercing tools used on electrical and similar work. They may cut at one time a complete set of openings around a circle or a segment, or they may be used with an indexing device for piercing out one or more notches at a time.

Similarly the dies that cut out the comb shaped slots in the piece, Fig. 12, are types of piercing devices known usually as Comb Dies.

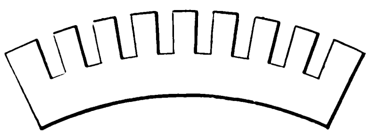


Fig. 11

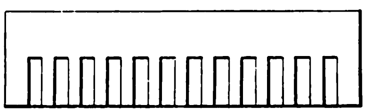


Fig. 12

Work performed in notching dies

Shaving Tools

Shaving Dies are employed on accurate press work where closest dimensions and sharp clean edges must be maintained on the work. These may be in the form of external shaving tools for finishing around the outer edges of a blank produced in an earlier operation, or they may be used with equally good results for internal cuts as in finishing the edges of a slot or an opening of any shape produced by piercing tools.

They form one of the most important types of tools for assisting the die maker to secure best results as to accuracy of product. Ordinarily they are made to remove a very thin shaving around the edge of the blank, say only a few thousandths at the most, and sometimes reshaving tools are used to follow the first shaving dies, to insure perfectly smooth and accurate edges on the blank. If, in blanking, too small an allowance is left for shaving, it is not always possible to produce a perfectly clean, smooth contour; and, furthermore, a reasonable allowance tends to increase the life of the dies by permitting them to take a clean cut around the blank without likelihood of very thin chips wedging in between the working faces of punch and die.

Shaving operations are usually performed by dropping a blanked piece into a nesting or locating device on the top of the shaving die. Occasionally, however, where only a small portion of a piece requires shaving, as with some important working surface on a piece that is otherwise of only ordinary degree of accuracy, the shaving operation may be accomplished before blanking by piercing out an opening in the stock around the surface to be shaved, then shaving the accurate portion, and following by blanking out the piece, this method involving the use of a progressive or follow die in

which the three operations are carried on at once for as many pieces after the stock has been advanced clear into the dies.

A shaving die of interesting construction is illustrated by Fig. 13, from which it will be gathered that in general appearance the shaving tools

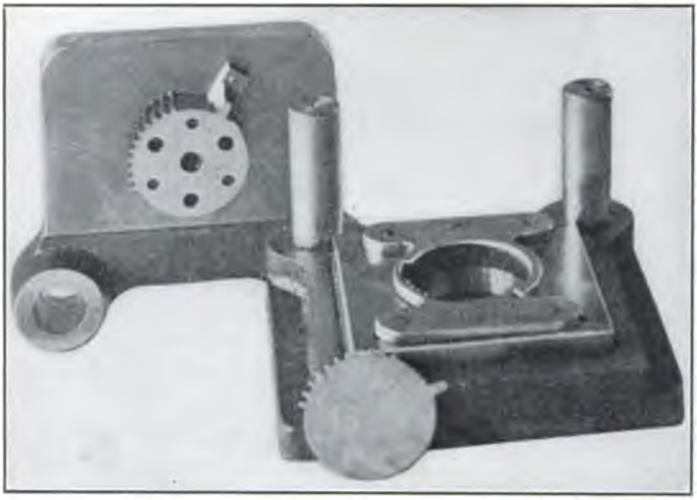


FIG. 13. — A shaving die for a toothed blank

closely resemble blanking dies except for the special nesting plate placed over the die proper in place of the customary stripper required for blanking tools.

CUTTING-OFF OR PARTING DIES

Cutting-off or shearing tools, like others included in press working operations, are constructed in various ways and for various classes of work. In simplest form they are employed for severing flat, round, and other stock, and often are fitted with other tools in the same set of dies for cutting off a piece from the strip of stock after certain other operations have been performed.

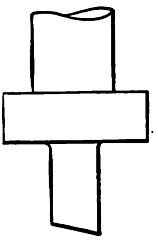


FIG. 14. — Punch with sheared cutting edge

When made solely for cutting across a piece of metal it is possible to give their edges considerable "shear" or slope, as in Fig. 14, to enable them to cut more freely, if desirable. Oftentimes they are shaped to give some special curve or form to the end of the piece cut off and a similar shape to the leading end of the next piece. Thus the tools are made symmetrical and the same stroke that cuts off the last end of the one piece also shapes the first end of the next,

which will in turn be cut off to shape when the stock is fed forward and the punch makes its next down stroke.

This design balances the cut on opposite sides of the flat ended punch and allows a single tool to operate on the ends of two pieces at once.

Trimming Dies

Trimming dies are used for cutting off the flange or the extra metal on the ends or edges of articles that have been made by some kind of blanking, forming, or drawing process where an irregular edge or a small amount of metal in the nature of a fin has been left which must be trimmed off to bring the work to finished condition. An example of such tools as applied to a drawn shell with the work ready for trimming and also with the edge finished by passing through the dies is seen in Fig. 15. The punch is so formed as to enter the drawn work and pass it down through the die with the result that the flared open edge is trimmed smoothly all the way round. The cutting action of the trimming tools is like that of an ordinary set of blanking dies except that the punch is really piloted to enter the work and support it during the movement past the cutting face of the die. Trimming dies are used extensively on flat blanks as well, and also for cutting out certain portions of the edges of various classes of parts, round, square, and of other form.

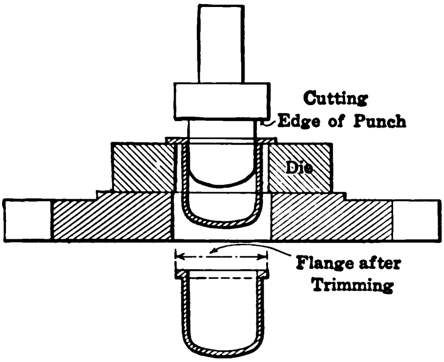


Fig. 15. — A flange trimming die

Hollow Cutting Tools

The old shop term Dinking Dies applies to a certain type of blanking die which is used for many materials softer than sheet metals. While in principle they are similar to some forms of blanking tools for metal work, they differ in having, usually, a rather keenly beveled cutting edge which cuts through the material, leather, paper, or other, in the same free manner that, to employ a homely comparison, a biscuit cutter passes through the rolled out sheet of plastic dough.

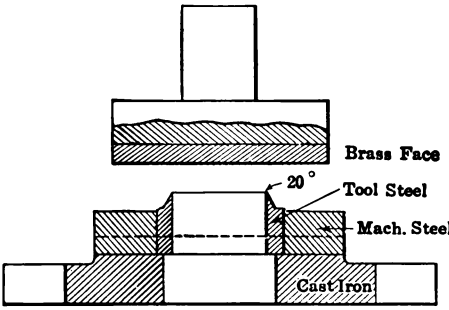


Fig. 16. — Dies for blanking fiber

Examples of tools for cutting leather and fiber are included in Fig. 16.

Their edges, according to the material to be cut, are commonly sloped to an angle of twelve to twenty degrees, and in some cases the interior is fitted with some form of ejecting device corresponding closely to that employed in metal working dies for parts of similar form. The punch is faced with soft brass or wood according to the material to be cut.

The foregoing examples of various kinds of dies for blanking, piercing, shaving, etc., give, in skeleton form, some of the essential elements of the different forms of press tools that operate by cutting or shearing the material. They will be taken up in considerable detail in other sections of this book.

We may now turn to another class of dies, those that operate by drawing or stretching the metal from the flat surface to the special form desired.

THE DRAWING PROCESS

When we take a piece of flat stock, brass, steel, or other metal, and push it through a round die by means of a dull ended punch which cannot cut through the stock, we "draw" the blank into a cylindrical shell, and if our punch and die have been of such size as to allow for the full thickness of the metal between the punch and the interior of the die, the area of the drawn shell will be practically that of the plain disc blank from which it started. That is, the operation accomplished is one of simple drawing without appreciable "stretching" of the original area, although the form of the work has passed through a decided change in which certain elements of the metal have been locally closed or compressed to a degree, and others directly opposite, stretched correspondingly.

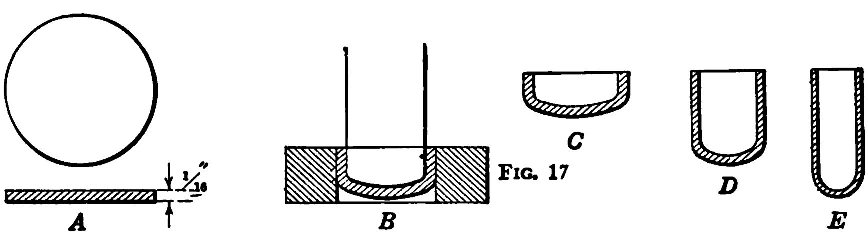


Fig. 17. — Drawing dies

Consider for a moment the thin disk in Fig. 17. Say we have a brass blank A $\frac{1}{16}$ inch thick, and of given area, we can force it down through the simplest form of drawing dies at B and produce the cup C which, with certain proportions between punch and die, will have practically the same total area as the round blank A. By repeating the drawing operations with smaller dies and punches we reduce the diameter of the cup and extend the length into a short shell D and then into a longer, smaller shell E. Still, it is usually possible if necessary to hold the original area of surface, indicating that under such conditions while the metal has been bent,

stretched, and compressed, at certain portions, the general body of the metal has not been stretched as a whole.

But, in usual drawing processes it is desired to stretch the original metal out as the operations proceed, gradually reducing the thickness proportionately to the length of the "draw" and generally bringing the completed shell to a fairly thin section as compared with the original blank. Occasionally, however, metal is encountered which will not permit of marked if any reduction in thickness by the drawing process, and in such cases the stock is selected of the same thickness as is desired for the finished product. The drawing or flowing under tension of the thicker metal as it is thinned down by being elongated in the drawing dies tends to harden the material, and with the majority of work where a number of drawing operations are necessary to complete the piece it is essential to anneal the shell between successive draws, otherwise the stock will tear apart, or the bottom of the shell be punched out, an indication of the decided degree of tension that the material is subjected to under usual conditions of drawing.

Action of Drawing Tools

The combined action of the punch and the opposing die surface tend to "iron" out the surface of the metal as it is drawn into the cup form and prevent undue wrinkling during the shallow draw. As the cup is redrawn step by step into longer shells, in successive dies, the reduction in each stage is limited and with properly made tools undesirable wrinkling is avoided.

Where deep draws are made, and particularly where blanks of the larger sizes are drawn up, the simple drawing tools indicated in the sketch, Fig. 17, are replaced by double action dies which operate in conjunction with a pressure pad for holding the blank under a definite degree of pressure and ironing it out as it is pulled under the pad and down into the drawing die. Such tools are used in presses which have an outer slide for carrying the pressure pad and gripping the blank, while an inner slide carries the regular drawing punch down into the die.

There is also a class of drawing tools such as combination dies, and another type, compound dies (used extensively also for blanking and piercing), where work requiring shallow drawing may be both blanked and formed or drawn to depth and pierced if so desired at one stroke of the machine, the tools carrying their own pressure pads and being used in simple presses. These types of dies will be described more fully in their proper places.

Reducing Dies

Reducing dies, as pointed out before, are commonly used for tapering and reshaping the end or some portion of a shell which requires a neck smaller than the body of the work. They are considered as a special form

of redrawing die, though their action is to close the end of the shell to a certain extent rather than to lengthen the body proper. One of the most common types of dies of this character is that used for reducing the necks of cartridge cases, as in Fig. 18, where a plain taper form is imparted, as at *A*, by the first die and the neck completed by a second die as at *B*.

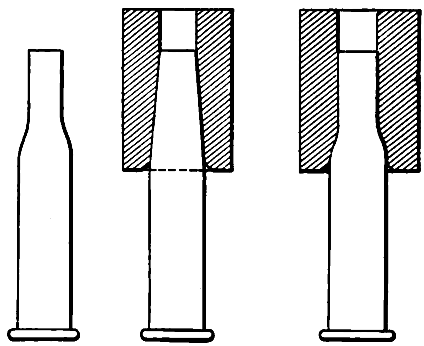


Fig. 18. — Reducing dies

Bulging Dies

Bulging dies act in the opposite manner to expand the body of an article, as in Fig. 19, where the work is shown placed over a plunger in the die which rests upon a thick body of rubber so that as the punch descends and forms the top of the work to the desired shape, the rubber is forced outward by the compression of the plunger head, causing the shell to expand outward into the die chamber. Upon the up stroke, the rubber returns to its original dimensions and the work is removed.

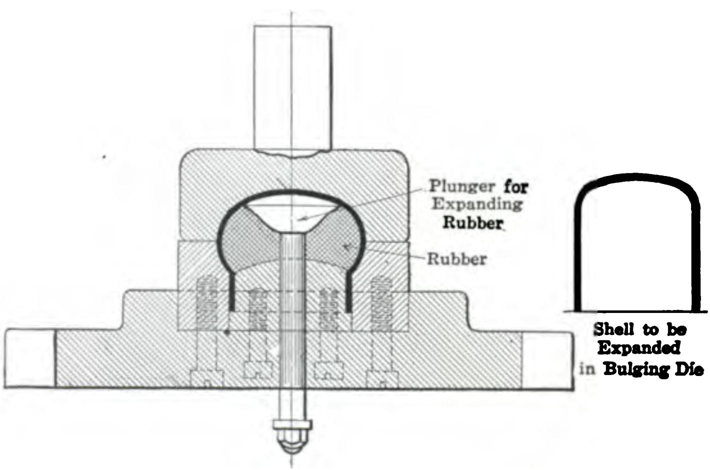


Fig. 19. — Bulging dies

Fluid dies are sometimes used for expanding work into an artistic mold-like device, the liquid being placed in the shell to be formed and the plunger carried by the press then acting upon the fluid to force the hollow shell into the design formed in the die or mold. Both the mechanical bulging die and the fluid type are employed principally for soft metals and are seldom seen in the general shop, although both types are occasionally used for steel and other relatively hard materials.

BENDING AND FORMING TOOLS

These dies are made in great variety and operate upon all classes of work. In simplest form, say, in the case of a plain bending die, the outline of the bend which is to be imparted to the blank is formed on punch and die, as in Fig. 20, where the method of bending a simple form is indicated. Where a more intricate form is required, as in Fig. 21, a die with jaws that close in from the side is employed to form the ends of the piece over the

FIG. 20. — Simple bending die

sides of the punch which controls the inside of the work. Such work is frequently passed through two sets of dies, one for starting the outlines of the bend, the other for completing the work.

Where the ends of a flat blank are to be formed up into a curl, as in Fig. 22, similar side closing jaws or dies are fitted into the die base and these

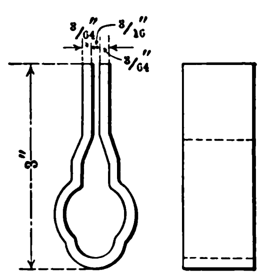


FIG. 21. — Piece formed with side closing die

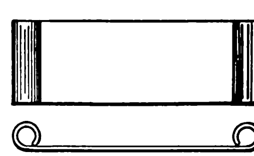


FIG. 22. — A curled piece

act to roll over the end of the blank as shown. The die is then strictly a curling tool and if it should further include provision for enclosing a piece of wire in the curled portion which is made to roll up around the wire, the tools would become curling and wiring dies.

It is usually a decided advantage and often strictly necessary to start a slight curl on the blank itself when it is produced in the first place in order that it shall curl in the proper direction when operated upon by the curling dies.

A curling and wiring die for cylindrical work, where a curled edge with wire stiffener is required on a shell or utensil, is represented by Fig. 23.

The construction is practically the same whether or not the wire is required, except that the mouth of the die for the wire may be modified to suit the diameter of the wire as indicated by the sketch.

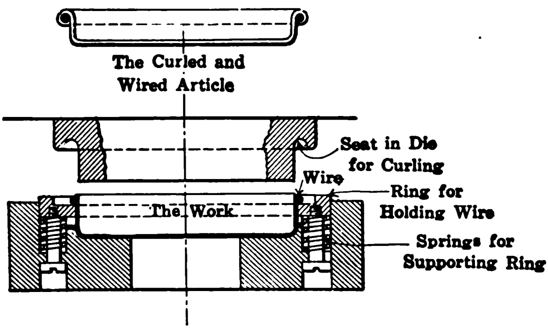


FIG. 23.— Curling and wiring dies

SWAGING DIES, EMBOSSING DIES, ETC.

Coming now to the class of dies that operate by swaging, or working the metal by upsetting, flowing, and forcing the mass into special forms desired, we may consider first the simple swaging die, Fig. 24. Such dies are used for shaping the edges and corners of blanks already punched out,

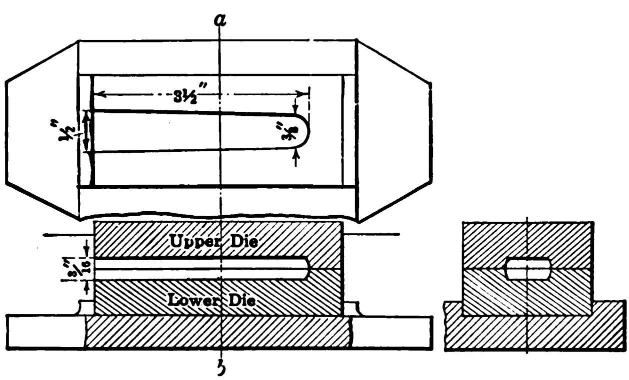


FIG. 24.— Swaging dies

and in this illustration the swaging dies are for a small handle which is finished properly along its edges by placing it in the dies, thus saving the trouble of grinding or filing corners.

A great deal of work is finished in this manner, the swaging process giving a suitable rounded shape to flat sections and forming corners and edges smoothly and to a neat finish.

Sometimes where numbers, names, or other markings are to be im-

pressed into the surface of a blank the operation is combined with that of swaging. In other cases the characters are stamped on the work before it is blanked out.

Embossing Dies

There are several distinct types of embossing dies, among the most commonly employed being those used for making jewelry and similar manufactures. The making of such dies is a highly specialized art of itself which hardly falls within the field of the present book. The die proper is struck up from a master or hub which is an exact duplicate of the work to be produced.

Embossing dies, so called, for operating on sheet metal parts are often

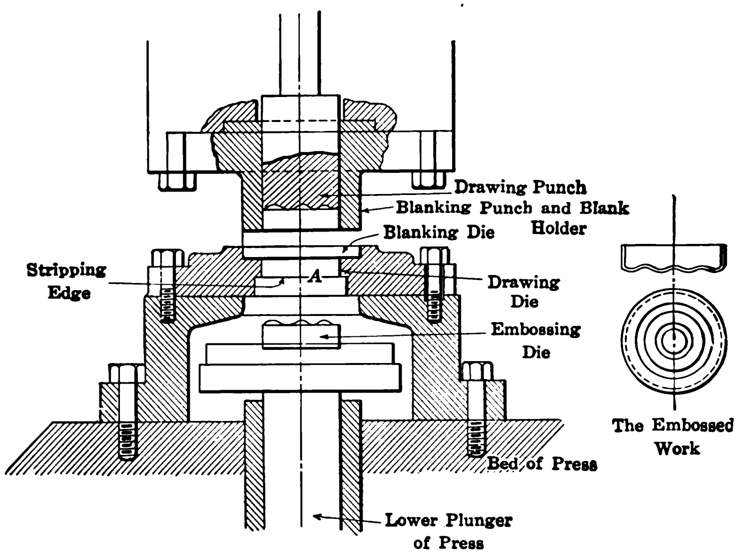


Fig. 25. — Embossing dies

used in conjunction with blanking tools or with blanking and drawing tools combined. In the latter instance, what are known as triple action dies are sometimes employed, these being operated in a triple acting press.

A set of dies of this character is shown in Fig. 25, in sectional view to represent all parts clearly. The press has double slides above to operate the blanking punch and the drawing punch inside of the latter, and under the die bed is another slide known as a plunger, which actuates the embossing die and forms the impression on the end of the shell drawn up after the drawing punch has carried the work down to the face of the embossing die. The stripping of the finished work from the drawing punch is accomplished on the up stroke by the edge A.

Coining Dies

Coining dies form another special line of tools and a type which is operated under very heavy pressures in machines of the embossing press class used for striking up jewelry, medals, and many other lines of work where clear cut designs are required in relief on the surface of the object.

The design for a coin is cut on both upper and lower dies *A*, *B*, as represented in Fig. 26, and after the blank *C*, or planchet, as the coin disk is called, has been struck up, the lower die rises through the collar or surrounding die, and carries the completed coin to the top where it is discharged from the press.

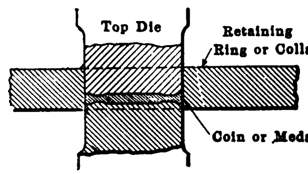


Fig. 26. — Coining dies

Heading Dies

A common example of the type of die used for heading is found in the tool used for striking up the heads of shells, say, for cartridges, and similar articles and dies of this character are most frequently employed in special horizontal machines, although they are also used in various forms in regular vertical presses. A head formed on a cartridge case by regular heading dies is seen in the illustration, Fig. 18.

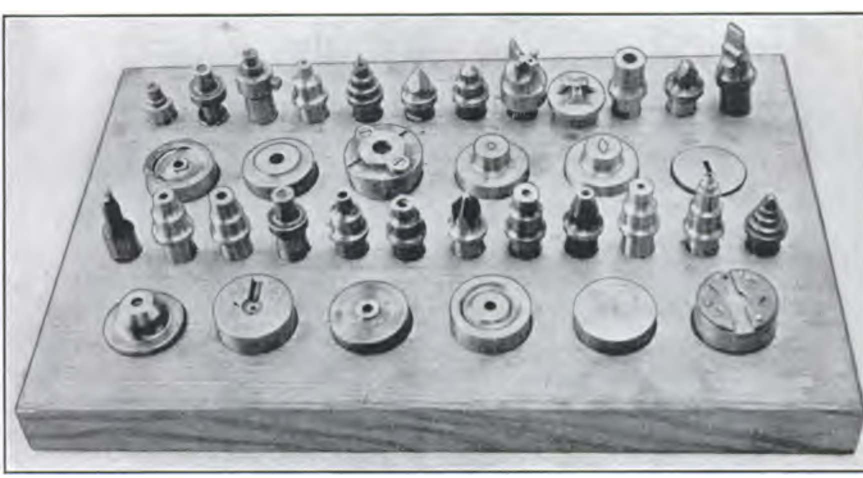


Fig. 27. — Tools for riveting and staking

Riveting and Staking Dies

These tools are used for fastening parts together and are made in great variety according to the form of the rivet or other fastening device which is to be operated upon. It is the usual custom where the pin, rivet, or post

to be fixed is a plain round piece, to speak of the tools as riveting dies, and where a square, rectangular, or irregular shape of stud or holding pin is to be "set" to call the tools staking dies. Riveting the operation consists in upsetting the end of the pin or rivet sufficiently to hold the parts securely. Usually staking requires but a single stroke or blow of the punch to spread the metal to hold the pin fast in the hole in which it fits, and generally a staked pin or other piece is flush with the face of the member in which it is set, while with riveting, strictly speaking, the end of the rivet projects above the surface sufficiently to permit of the forming of a regular head under the application of the punch. Both riveting and staking tools are shown in Fig. 27.

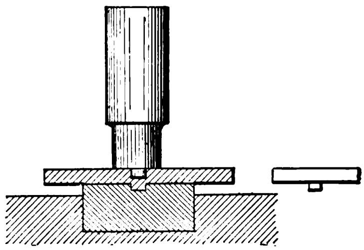


Fig. 28. — Extruding tools

Extruding Dies

These tools as considered for punch press operations are employed for such work as forcing out from the flat surface of a blank, a pin or other projection which may be needed for pivoting or riveting the piece to some other member. The action upon the material is quite like that of embossing, but for the purpose indicated, the metal caused to protrude from the face of the work is generally a small pin or plug-like extension, as shown by Fig. 28 where the piece is seen between the punch and die. The rivet or plug thus left projecting from the surface is integral with the body of the metal and forms a secure and convenient device for the purpose of locating or fastening the piece to some other part, or for receiving some other member that is required to operate upon a post or stud.

The action of the extruding punch upon the metal is to cause it to flow ahead into the die and with properly made tools a clean accurate projecting pin is formed which, for various purposes, has many advantages over the more common rivet as usually employed.

CHAPTER II

BLANKING DIES

Blanking dies, the most commonly used of all press tools, are made for an infinite variety of parts and for work of all sizes from very small pieces to large rectangular, circular, and other forms, ranging sometimes up to several feet in length or diameter. In elementary form, blanking tools consist merely of a simple punch and die of the kind illustrated in Fig. 2, in the preceding chapter, but as developed for larger work and particularly for parts of irregular outline, they assume more intricate forms and

FIG. 29. — Examples of blanked parts

are oftentimes made up of a large number of sections fitted together to cover the entire outline of the blank, the sectional design having many advantages in first construction and later on in the upkeep. This form of die will be described in detail in the present chapter.

First, however, certain characteristic sets of blanking tools for small parts will be illustrated, such, for example, as are employed for producing blanks similar to some of the pieces represented herewith in Fig. 29. This group of blanks for calculating machine parts is composed of a variety of small shapes, and as this chapter continues, other and larger pieces blanked by similar means will be shown, in connection with the dies with which they are made.

Blanking and Other Operations

It has been pointed out that blanking operations are often combined with other processes; thus piercing and blanking dies are very commonly combined in the one set of tools, and various forms of blanking and drawing dies, blanking and forming tools and other sets for performing two or more operations in one pair of dies are used in common practice. The present chapter however will be restricted to blanking dies as such, without reference at this point to the numerous forms in which they are made up as one pair of dies which carry also piercing, drawing or other tools.

Furthermore, it will be left to another section of this book to illustrate certain interesting examples of blanking dies which constitute first operation tools in complete sets of dies where the blanking process is followed in other tools by such operations as piercing, bending, forming, drawing and

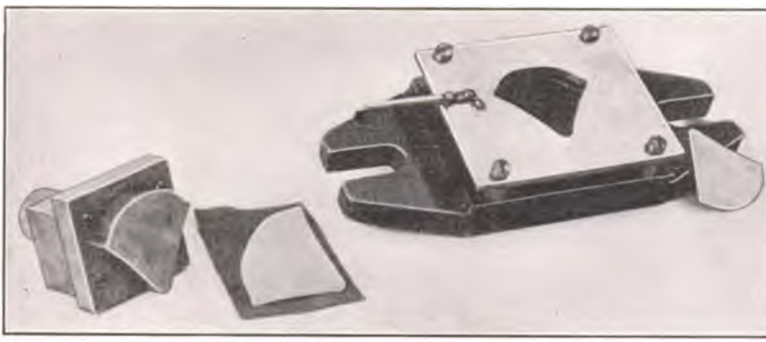


Fig. 30. — A set of open blanking dies

so on. In this connection, the blanking dies will be described in their respective relationship to the other tools in the series, and the effect which subsequent operations have upon the design of the blanking tools will be discussed fully.

We may now take up certain types of blanking dies by themselves and consider various details pertaining to their construction. In order to bring out different points of importance a number of examples have been selected representing the practice of several shops where punch and die-making forms a very large part of the tool room work.

Simple Open Die

The set of tools in Figs. 30 and 31 is for blanking out an aluminum piece of triangular form to the dimensions on the sketch, Fig. 32. The thickness of the piece is approximately $\frac{3}{64}$ inch or No. 16 B. & S. gage. It is a blank which is afterward bent up into a U-form, but the material, gage and purpose of the blank are of no especial importance here as the illus-

trations are merely to show a simple form of blanking die, of the open type, that is without guide pins, and to represent the different parts in detail.

These parts are clearly shown in Fig. 31 where the die is taken apart. The supports for the stripper plate will be best seen, however, in the other

FIG. 31. — Blanking tools taken apart

view, Fig. 30. They are simply short bushings which hold the stripper at the right distance above the die face and allow the attaching screws to pass through. This is, of course, only one way of spacing the stripper above the die. It is much more common practice to use a strip of metal at front or back or along both edges, to hold the stripper; or to make the stripper from heavier metal and cut out a channel in its under side to allow the stock to be fed through.

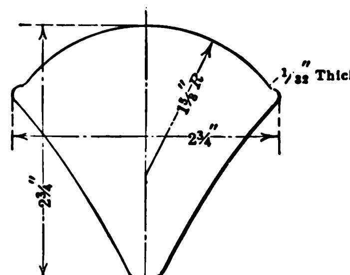


FIG. 32. — The blank produced in the tools in Fig. 31

STOCK STOPS

The die illustrated in these views also carries one of the simplest forms of stock stops, a short projecting pin, bent down at the outer end as seen at the left of the die in Fig. 30. This stop is attached to the stripper and its position is such as to enable its bent end to engage with the openings punched in the strip of material as the blanks are produced one by one and the stock advanced step by step to the left in being fed through the dies.

The details of stock stops in numerous forms and nests or locating devices for second operation dies are sufficiently important to justify special description which will be accorded them with various other die details in other chapters.

It will be noticed that the punch proper in Fig. 31 is adapted to be attached to the shank by means of fillister head screws. Here is another detail in respect to which there is wide divergence in the practice of different shops. A common method is to make the punch, if not too large, with a solid shank if the dies are of the open type here shown, and fit the shank either directly into the press slide or into an auxiliary shank or adapter which itself enters the slide of the press. Practice in this respect and with other details of punches and dies will be taken up in due course.

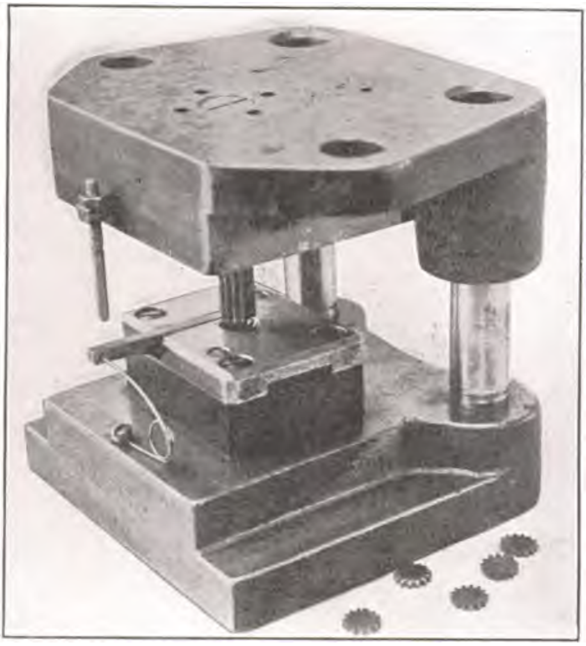


Fig. 33. — A wheel blanking die of the sub-press type

A Pillar Die

Turning now to blanking tools of the pillar type, that is with guide pins to preserve alinement between punch and die, so that they are operated on the sub-press principle, we have, in Figs. 33 and 34, an interesting example. This is a wheel die for a small toothed blank with outside diameter of $\frac{7}{16}$ inch, and 13 teeth. It is of cold rolled steel 0.090 inch thick, or rather heavy metal for so small a blank. Several blanks are included in the group referred to in connection with Fig. 29 and others will be seen in the two tool photographs, Figs. 33 and 34.

The pillar die, or sub-pressed die, is by no means confined to operations on small work of the kind here shown. As already stated, modern practice in press tool work tends to a rapid adoption of this form of die for large as

well as small pieces, and not only for blanking operations but for shaving, piercing, forming, and other press processes.

The pillar die has indeed become so generally used for a great variety of press work that a majority of the illustrations in this book will be confined to examples of that form of construction.

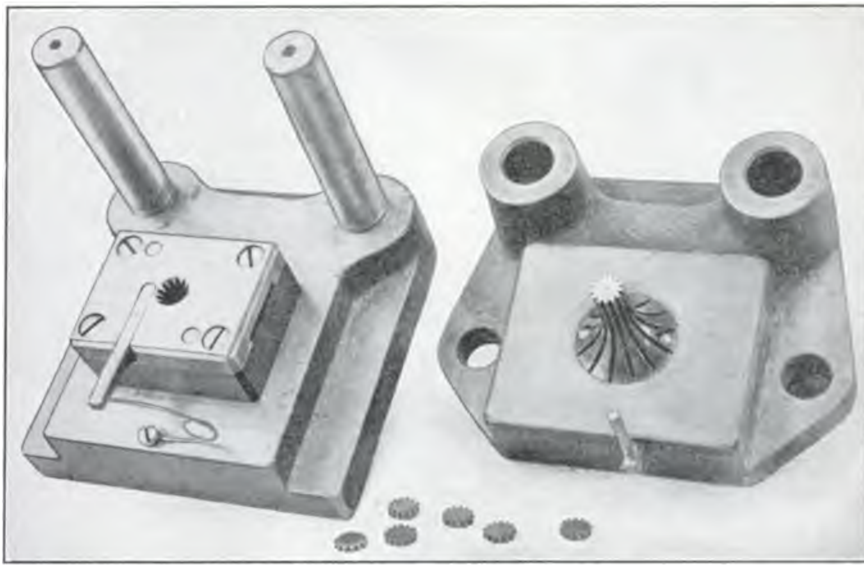


FIG. 34. — Punch-head removed from guide pins

WHEEL DIE DETAILS

A drawing of the wheel die, Fig. 33, is reproduced in Fig. 35. This shows all details clearly and brings out distinctly the method of locating the punch in the head or upper member, and the die on its base. The former, as will be observed, is made with a flanged circular base and hub to enter the seat bored in the cast iron head; while the die itself is secured by four screws to the lower member or base proper. The punch is positioned by two $\frac{3}{16}$-inch dowels and two $\frac{1}{4}$-inch dowels are used in the die.

The stripper is of the type which is made of one piece milled out to form a free passage for the strip of stock. The stock stop is in the form of a rocker or trigger with light spring to hold it down normally with its hooked inner end in the path of the stock. When the press slide descends the contact screw *A* carried by the punch head strikes the stop *B* and causes the inner end to rise so that when the slide and punch start to ascend the stop clears the strip of stock momentarily and permits it to be fed forward to be engaged again by the stop which has been released at the instant the punch has cleared the die.

A single $\frac{5}{16}$-inch by 18-thread screw secures the punch in its seat, the screw having a countersunk head to come just below the face of the holder. The die screws are four in number and are $\frac{1}{4}$ by 20 thread, fillister head screws. The dowels are ground perfectly straight, and once in place there is no possibility of either punch or die shifting in its seat. Dimensions of all such locating and fastening member for different sizes of dies will be found in another section.

Materials Used

It is not the intention in this chapter to enter into a description of methods of making each and every part of the blanking dies covered by the illustrations. The actual work of the tool room with its high-grade hand and machine processes will, however, be described somewhat in detail later on, not only in connection with the making of blanking tools but also in reference to the production of other dies in their various forms.

In the present chapter it is the intention to set forth some general principles respecting the characteristic forms of blanking tools and some of the points that have to be observed by the tool maker who lays out and makes up the dies. These points include such items as the materials required, clearances in dies, allowances for stock in strippers, positions of stops, location of die in respect to the edges of the base in order to place the blank, say, longitudinally with the stock, or square across the strip, or at some angle to which its contour best adapts it. The interesting process of "finding" the blank, that is determining its exact outline and dimensions to enable later operations to draw it or form it into a finished article of the required shape and proportions, constitutes a special subject of itself which will be developed accordingly under its own specific chapter head.

Bases, Heads, and Pins

The tools in Figs. 33, 34, and 35 have die base and head of cast iron, both to standard dimensions in accordance with the sizes given in Chapter XV, at page 343. The pillars, or guide pins, for such tools are usually of a good grade of steel accurately ground to size, which gives them a close sliding fit in the holes bored in the head. Where tools of this form are operated more or less continuously on large lots of work, it is the practice in some places to bush the head and harden, grind, and lap both guide pins and bushings, thus preserving the wearing surfaces indefinitely and where replacement of worn parts eventually becomes necessary, simplifying the process appreciably.

Ordinarily, any given set of tools in the press room has a limited run, of a few days say, and then is put aside until another lot of similar work comes along. The rapidity with which such tools produce parts makes continuous operation with any one set of dies a rare event in the general

factory. Consequently there is relatively little wear on the guide pins and the corresponding holes in the head, and the surfaces will usually remain in good condition indefinitely.

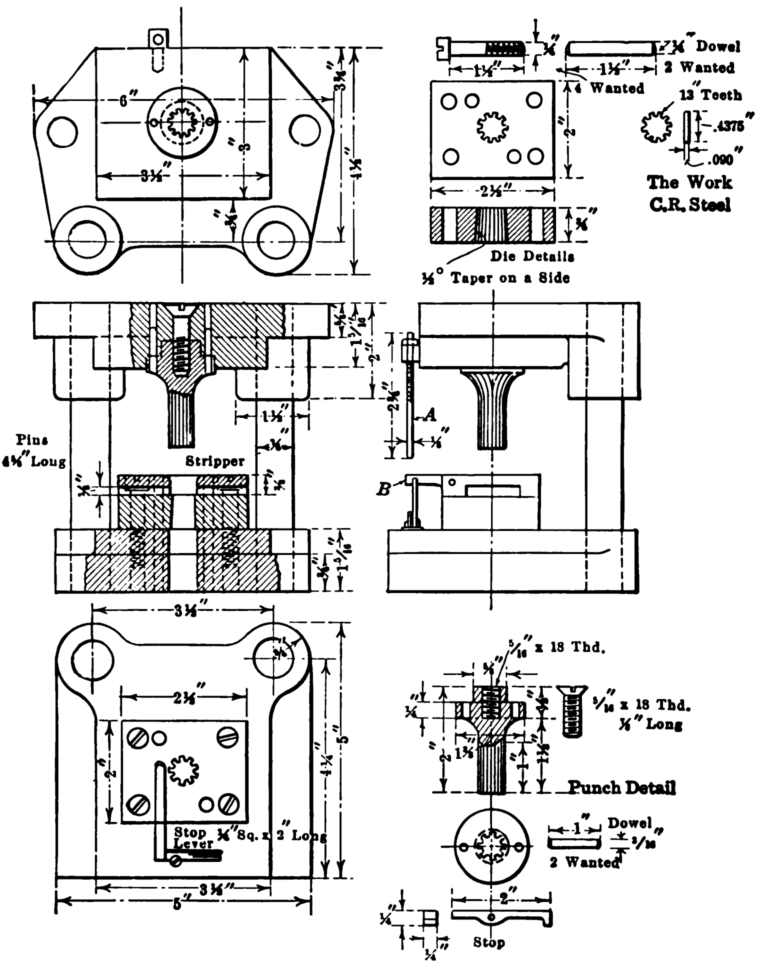


FIG. 35. — Details of wheel blanking die

Blanking Die Clearance or Relief

It is generally the practice in working out a blanking die to allow one-half degree relief or taper on each side as indicated by the sectional view of the die detail in Fig. 35. This will be sufficient in most cases, for slight though the amount of clearance or taper may be it accomplishes a number of results. It gives, primarily, a gradually increased area of opening in the die to facilitate the passing through of the blanks as cut out without likelihood of their wedging and jamming as successive blanks are forced down

upon them; it provides a nominal amount of rake at least, at the cutting edge of the die and to that degree aids in the free cutting of the blank. At the same time the amount of clearance or taper is so slight that in most cases the increase in the size of the blank as the die is sharpened by grinding across the face is negligible, even though the die is reground many times.

Advantages of Shaving Dies

As a matter of fact, while the factors of natural wear and the grinding off of the die face do necessarily result in a little enlargement of the blank, this is not a serious matter of itself, for the following reasons: In the first place, if blanked parts are to be held to an absolute size or if their edges are required to be perfectly smooth and with square, unbroken corners, they should be passed through a shaving die in a second operation where they will be brought to exact dimensions, and finished with clean, sharp edges. And, assuming they are to be shaved, the increase in the blank size, due to the condition of the blanking dies, should make no difference, for the shaving process will restore the piece to size even though one- or two-thousandths more are to be taken off than was originally planned for in laying out the shaving tools.

Shaving Dies Especially Serviceable

These shaving dies are especially useful when accurate work is to be maintained in the case of blanks that are rather heavy or of thick stock as compared with their diameter or width. Here, with the heavier material, it is more difficult to secure accurate, clean contours on the blank and often not only one but two shaving dies are used after the work is blanked to finish it as required, the amount removed by the secondary operations being divided properly between the two sets of shaving tools.

In the main, however, shaving dies are not extensively employed in the average shop for the reason that sufficiently close results for the greater part of press manufactured pieces are obtainable without them. It is also the case that where shaving dies could be utilized to great advantage in various ways, they are only too often disregarded entirely or are perhaps too little known in some classes of shops to be appreciated at their full worth. In some other shops they are commonly used for both exterior finishing of blanks and for shaving pierced openings as well.

Shaving tools of different kinds will be found illustrated in detail in Chapters VI and VII.

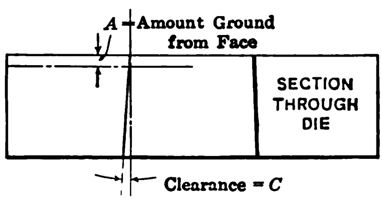
Table of Die Clearances or Relief

It is sometimes of value to know how much increase in blanking die size occurs as the face is ground down in resharpening and for this reason Table 1 has been worked out to cover various angles of taper besides the

conventional slope of ½ degree on a side. While the half degree taper relief or clearance from vertical line has been specified as almost universally used for the ordinary run of blanking dies, there are special instances where this angle has been exceeded appreciably, and this is especially true in respect to certain classes of piercing and perforating dies.

While, ordinarily, the angle of ½ degree on a side will allow of the free discharge of the slugs from perforated blanks, such materials as aluminum and similarly soft metals sometimes produce slugs that in the small sizes, particularly, tend to swage into the walls of the piercing die when forced

TABLE 1



A Amount ground from face of die in thousandths	C Clearance in thousandths corresponding to degrees on each side				
In.	½ deg.	1 deg.	1½ deg.	2 deg.	2½ deg.
0.010	0.000087	0.000175	0.000262	0.000349	0.000437
0.020	0.000175	0.000350	0.000524	0.000698	0.000873
0.030	0.000241	0.000525	0.000786	0 001047	0.001310
0.040	0 000378	0.000700	0.001048	0 001396	0 001746
0.050	0.000437	0.000875	0.001310	0.001745	0 002183
0.060	0.000524	0.001050	0.001572	0.002094	0 002620
0.070	0.000611	0.001225	0.001834	0.002443	0.003016
0.080	0.000698	0.001400	0.002096	0.003092	0.003493
0.090	0.000776	0.001575	0.002358	0.003141	0.003929
0.100	0.000870	0.001750	0.002620	0.003493	0.004370
0.110	0.000960	0.001925	0.002882	0.003839	0.004803
0.120	0.001047	0.002100	0.003144	0.004188	0.005239
0.130	0.001135	0.002275	0.003406	0.004537	0.005677
0.140	0.00122[illegible]	0.002450	0.003668	0.004886	0.006112
0.150	0.001309	0.002625	0.003930	0.005235	0.006549
0 160	0.001417	0.002800	0.004192	0.005584	0.006986
0.170	0.001484	0.002975	0.004554	0.005933	0 007422
0.180	0.001571	0.003150	0.004712	0.006282	0.007859
0.190	0.001658	0.003325	0.004978	0.006631	0.008295
0.200	0.001746	0.003500	0.005240	0.006980	0.008732
0.210	0.001827	0.003675	0.005502	0.007329	0.009169
0.220	0.001914	0.003850	0.005764	0.007678	0 009605
0.230	0.002001	0.004025	0.006026	0.008027	0.010042
0.240	0.002088	0.004200	0.006288	0.008376	0.010478
0.250	0.002175	0.004375	0.006550	0.008725	0.010915

down by the punch and because of the expanding action, due to the pressure upon their limited areas, these slugs may then stick, and stack up and, becoming welded together, are likely to cause the punch to break or the die to become chipped around the edges of the small hole. It is often the case that such slugs emerge from the die in all appearance like a small solid rod of material, built up of thin disks or slugs pressed firmly together.

The table of various angles with corresponding diameters at different points in the thickness of the die may therefore be of interest in connection with piercing dies as well as blanking tools.

Explanation of the Table

The table is arranged to show the additional amount at each side of a die for every depth of ten-thousandths ground off of its top face. This, by the way, is much more than the average amount removed in one grinding of an ordinary die, but it is a convenient increment to work from and the quantities in the columns that follow are very readily modified to correspond to any specified amount taken off the die face in the grinding operation.

Consider the half-degree column: The increase at each side of the die is entirely negligible when the first 0.010 inch has been ground from the face, and only after the die has been ground down 0.120 inch or almost $\frac{1}{8}$ inch does the diameter of the die become 0.001 inch greater on each side or 0.002 inch more over all.

The Life of a Die

It is obvious from the table, that, even with angles of side clearance greater than the common one of $\frac{1}{2}$ degree there is little change in the die size until a considerable amount has been removed from its face.

Usually an enormous quantity of work can be produced in a die before its over-size becomes objectionable; and in case the blank is to be shaved subsequently, there is an even greater period of service possible before the slight addition to the blank size has to be taken into consideration.

With fairly small blanking dies, such, for example, as we have been considering for producing the gear wheels in Figs. 33 and 34, it is usually unnecessary to grind off more than, say, 0.005 inch for each resharpening operation. Before grinding becomes necessary at all, at least 30,000 steel blanks will have been produced and this means that with the same output after each grinding, something like 1,500,000 blanks can be made before the die has been reduced one-quarter of an inch in thickness. And this is only a part of the entire die at that.

With lighter gage stock and softer material the amount of work blanked in such a die between sharpening operations is greatly increased.

Another Form of Die

This feature of large quantity production between successive grindings enables another form of blanking die to be used occasionally, particularly on such parts as toothed wheels where it may be preferred to have the die perfectly straight for a certain distance up and down, without giving it side clearance in the usual manner.

Such a die is shown at *A*, Fig. 36, and for ready comparison, the usual die with straight taper inside of ½ degree on a side is shown directly above at *B*, Fig. 37. The die *A*, it will be seen, is formed straight down from the top for a depth of ¼ inch and below that has the usual angle at the side. The straight upper portion, however, should in accordance with the figures given above, produce a million and a half pieces before it has been ground to the point where the tapered portion begins, and it thus gives the advantage of a construction where no change occurs in the size of the blanks (except for the unappreciable amount of wear in the die itself) until the actual depth is reached in grinding where the half degree taper commences.

It is quite apparent that, eliminating possibility of accidents, such a set of dies would be apt to answer for any but exceedingly long runs of work, and in most cases would not require replacement before some modification in the work itself would render necessary a new set of dies throughout.

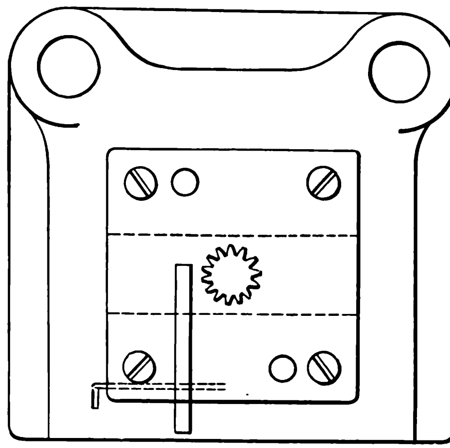


Fig. 37

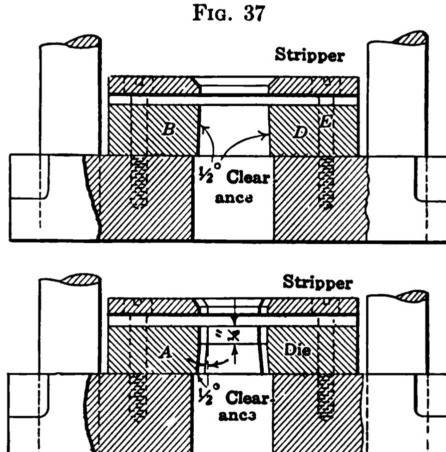


Fig. 36
Two methods of relieving dies

Clearance Between Punch and Die

Theoretically a blanking punch is not supposed to enter the die opening when in operation but to stop at the end of the down stroke of the press

slide with its lower end practically flush with the face of the die. There is a definite percentage of clearance between the punch and the die, the punch being smaller by an amount dependent upon the thickness of the stock and the character of the material, whether hard, soft, etc. On very small work and where very thin metal is blanked, the punch is nominally the size of the die. But with heavier stock the clearance between punch and die becomes an appreciable quantity.

For any given kind of sheet metal the amount of clearance allowed between punch and die is based upon the thickness of the metal and varies directly with the gage of the stock. Considered in respect to different classes of material, the clearance is greater for hard rolled steel than for soft steel and brass. For very large dies there is a greater percentage allowed for clearance than for small dies, but for the general run of sizes there is close uniformity for any specific grade of work.

There must not be excessive clearance in any case for this may result in slight curling up, or bending of the edge along the blank, and prevent a smooth even cut from being produced. Table 2 has been computed to cover clearances for all gages of material in the three gage standards commonly used for sheet metal.

Table of Clearances Between Punch and Die

This table has been worked out to give clearances based upon various percentages of stock thickness ranging from 5 per cent to 12 per cent. The first column is arranged to advance by increments of 0.005 inch, and directly opposite, under the respective gage headings, are grouped the actual gage equivalents most closely corresponding to the thickness in the first column.

Of the six columns of clearances, the first three are particularly adapted to very accurate work and small parts especially, 5 per cent being the allowance computed for Brass and Soft Steel; 6 per cent for Medium Rolled Steel; and 7 per cent for Hard Rolled Steel. Similarly, the other three columns cover the general run of work where a little more clearance is permissible, 8 per cent being here allowed for Brass and Soft Steel; 10 per cent for Medium Rolled Steel; and 12 per cent for Hard Rolled Steel.

These clearances apply to piercing dies as well as to dies for blanking. In blanking, the die, of course, determines the size of the piece, and here the allowance between punch and die must be made in the punch, the die being made to the size required for the work, and the punch an amount smaller according to the allowances in the table. If the work is to be shaved after blanking, the allowance for shaving is necessarily added to the size of the blanking die and the punch is also made larger by a corresponding amount.

In reference to the sizing of work accurately in the blanking die, it may be pointed out here that while it is the generally accepted practice to make

TABLE 2

	Gage						Clearance between blanking punch and die based upon percentage of stock thickness					
	American or Brown & Sharpe		U. S. Standard for plate		Birmingham or Stubbs							
	No.	Thickness	No.	Thickness	No.	Thickness	5%	6%	7%	8%	10%	12%
	40	0.003144										
	39	0.003531										
0.005	38	0.003965					0.00025	0.0003	0.00035	0.0004	0.0005	0.0006
	37	0.004453										
	36	0.005										
	35	0.005614	38	0.00625	36	0.004						
	34	0.006304	37	0.006640	35	0.005						
	33	0.00708	36	0.007031	34	0.007						
0.010	32	0.00795	35	0.007812	33	0.008	0.0005	0.0006	0.0007	0.0008	0.001	0.0012
	31	0.008928	34	0.008593	32	0.009						
	30	0.010025	33	0.009375	31	0.010						
	29	0.011257	32	0.010156	30	0.012						
			31	0.010937								
0.015	28	0.012641			29	0.013	0.00075	0.0009	0.00105	0.0012	0.0075	0.0018
	27	0.014195	30	0.0125	28	0.014						
			29	0.014062								
	26	0.01594	28	0.015625	27	0.016						
0.020	25	0.0179	27	0.017187	26	0.018	0.0010	0.0012	0.0014	0.0016	0.002	0.0024
			26	0.01875	25	0.020						
	24	0.0201	25	0.021875	24	0.022						
0.025	23	0.022571	24	0.025	23	0.025	0.00125	0.0015	0.00175	0.0020	0.0025	0.0030
	22	0.025347	23	0.028125	22	0.028						
0.030	21	0.028462					0.00150	0.0018	0.0021	0.0024	0.0030	0.0036
	20	0.031961	22	0.03125	21	0.032						
0.035	19	0.03589	21	0.034375	20	0.035	0.00175	0.0021	0.00245	0.0028	0.0035	0.0042
0.040	18	0.040303	20	0.0375	19	0.042	0.002	0.0024	0.0028	0.0032	0.004	0.0048
0.045	17	0.045257	19	0.04375			0.00225	0.0027	0.00315	0.0036	0.0045	0.0054
0.050	16	0.05082	18	0.050	18	0.049	0.0025	0.0030	0.0035	0.0040	0.0050	0.0060
0.055	15	0.057068	17	0.0562			0.00275	0.0033	0.00385	0.0044	0.0055	0.0066
0.060					17	0.058	0.003	0.0036	0.0042	0.0048	0.006	0.0072
0.065	14	0.064084	16	0.0625	16	0.065	0.00325	0.0039	0.00455	0.0052	0.0065	0.0078
0.070	13	0.071961	15	0.070312	15	0.072	0.0035	0.0042	0.0049	0.0056	0.007	0.0084
0.075							0.00375	0.0045	0.00525	0.0060	0.0075	0.0090
0.080	12	0.080808	14	0.078125			0.004	0.0048	0.0056	0.0064	0.008	0.0096
0.085					14	0.083	0.00425	0.0051	0.00595	0.0068	0.0085	0.0102
0.090	11	0.090742					0.0045	0.0054	0.0063	0.0072	0.009	0.0108
0.095			13	0.09375	13	0.095	0.00475	0.0057	0.00665	0.0076	0.0095	0.0114
0.100	10	0.10189					0.005	0.0060	0.007	0.0080	0.010	0.0120
0.105							0.00525	0.0063	0.00735	0.0084	0.0105	0.0126
0.110			12	0.109375	12	0.109	0.00550	0.0066	0.00770	0.0088	0.011	0.0132
0.115	9	0.11443					0.00575	0.0069	0.00805	0.0092	0.0115	0.0138
0.120					11	0.120	0.006	0.0072	0.00840	0.0096	0.072	0.0144
0.125			11	0.125			0.00625	0.0075	0.00875	0.0100	0.0125	0.0150
0.130	8	0.12849					0.00650	0.0078	0.00910	0.0104	0.013	0.0156
0.135					10	0.134	0.00675	0.0081	0.00945	0.0108	0.0135	0.0162
0.140			10	0.140625			0.007	0.0084	0.00980	0.0112	0.014	0.0168
0.145	7	0.14428					0.00725	0.0087	0.01015	0.0116	0.0145	0.0174
0.150					9	0.148	0.0075	0.009	0.01050	0.0120	0.015	0.0180
0.155							0.00775	0.0093	0.01085	0.0124	0.0155	0.0186
0.160	6	0.16202	9	0.15625			0.008	0.0096	0.01120	0.0128	0.016	0.0192
0.165					8	0.165	0.00825	0.0099	0.01155	0.0132	0.0165	0.0198
0.170			8	0.171875			0.00850	0.0102	0.01190	0.0136	0.017	0.0204
0.175							0.00875	0.0105	0.01225	0.0140	0.0175	0.0210
0.180					7	0.180	0.009	0.0108	0.01260	0.0144	0.018	0.0216
0.185	5	0.18194					0.00925	0.0111	0.01295	0.0148	0.0185	0.0222
0.190			7	0.1875			0.00950	0.0114	0.01330	0.0152	0.019	0.0228
0.195							0.00975	0.0117	0.01365	0.0156	0.0195	0.0234
0.200							0.0100	0.0120	0.01400	0.0160	0.020	0.0240
0.205	4	0.20431	6	0.203125	6	0.203	0.01025	0.0123	0.01435	0.0164	0.0205	0.0246
0.210							0.01050	0.0126	0.01470	0.0168	0.021	0.0252
0.215							0.01075	0.0129	0.01505	0.0172	0.0215	0.0258
0.220			5	0.21875	5	0.220	0.0110	0.0132	0.01540	0.0176	0.022	0.0264
0.225							0.01125	0.0135	0.01575	0.0180	0.0225	0.0270
0.230	3	0.22942					0.01150	0.0138	0.01610	0.0184	0.023	0.0276
0.235			4	0.234375			0.01175	0.0141	0.01645	0.0188	0.0235	0.0282
0.240					4	0.238	0.01200	0.0144	0.01680	0.0192	0.024	0.0288
0.245							0.01225	0.0147	0.01715	0.0196	0.0245	0.0294
0.250	2	0.25763	3	0.250	3	0.259	0.01250	0.0150	0.01750	0.0200	0.025	0.0300

the die to the exact dimensions required for the blanked piece, some authorities recommend making the die undersize by two-thousandths of an inch, allowing clearance on the punch as usual and shearing the die. The shear on the die gives a freer blanking action tending to greater accuracy in the work and at the same time it lengthens the cutting opening in the die in direct proportion to the degree of shear given the die face.

Thus if a die is, say, two inches long across the opening and it is given $\frac{1}{16}$ inch shear, or say 2 degrees, the actual distance, as now measured across the die opening to which the work will be blanked, is nearly 0.002 inch more than when the die face was parallel with the punch. This is compensated for by making the minus allowance of 0.002 inch as given above.

Also, with flat dies, where the stock is of heavy gage, there is a slight tendency for the blank to compress and the die to open by a very small amount, so some tool rooms adopt the practice of making the die a slight amount under size to offset this tendency.

Pressures Required for Blanking

The action of blanking tools is to shear the metal by cutting the blank through the stock, and knowing the shearing strength of a given grade of material it is possible to make up a table that will show approximate pressures necessary to blank a certain size piece. These pressures represented in pounds are necessarily approximate only, for various factors entering into each case modify the theoretical values from which the table is compiled. Such factors are the condition of punch and die at the time; the degree of clearance; the general outline of the work whether plain edged or complicated by various projections; the character of the cutting faces of punch and die, whether flat or sheared, and, if the latter, the degree and nature of the shear, etc.

Table 3 is based upon a unit length of shear of 1 inch with approximate pressures in pounds for different thicknesses of metal with one inch length of cut. Where the outline of the work is 2, 3, 6, 8 inches long or any other length, the corresponding pressure necessary is found by simply multiplying the quantity in the table opposite the thickness of stock by the actual distance around the piece.

This table has been computed for gages in the U. S. Standard Plate system only, but the thicknesses under these gage numbers correspond closely with other numbers in the American or B. & S. gage and the Birmingham gage so that by finding the nearest thickness in the table the corresponding pressures for the other gages mentioned are easily located in the table. A similar table for piercing dies, but based upon a one-inch diameter of hole, will be found in the Chapter on Piercing Tools.

TABLE 3. — APPROXIMATE PRESSURE IN LBS. FOR SHEARING BRASS AND STEEL FOR 1-INCH LENGTH OF CUT

Shearing strength of brass per sq. in. = 35,000 lbs.
Shearing strength of steel per sq. in. = 50,000 lbs.
Shearing strength of high-carbon steel per sq. in. = 75,000 lbs.

Gage, U. S. Standard plate		Lbs. pressure		
No.	Thickness	Brass	Steel	High-carbon steel
28	0.015625	546	780	1,170
27	0.0171875	595	850	1,275
26	0.01875	615	940	1,400
25	0.021875	770	1,090	1,635
24	0.025	875	1,250	1,875
23	0.028125	980	1,405	2,100
22	0.03125	1085	1,560	2,340
21	0.034375	1190	1,715	2,550
20	0.0375	1312	1,875	2,812
19	0.04375	1540	2,185	3,280
18	0.05	1750	2,500	3,750
17	0.05625	1960	2,810	4,200
16	0.0625	2187	3,125	4,687
15	0.0703125	2480	3,515	5,250
14	0.078125	2710	3,905	5,850
13	0.09375	3290	4,700	7,050
12	0.109375	3815	5,465	8,200
11	0.125	4375	6,250	9,375
10	0.140625	4935	7,030	10,500
9	0.15625	5460	7,810	11,700
8	0.171875	6020	8,598	12,900
7	0.1875	6562	9,375	14,062
6	0.203125	7075	10,155	15,225
5	0.21875	7667	10,935	16,425
4	0.234375	8190	11,715	17,550
3	0.250	8750	12,500	18,750
2	....	....	....	....
1	....	....	....	....

Rule: Multiply thickness of stock by length by shearing strength of material

THE EFFECT OF SHEARED TOOLS

Where the tools are sheared, that is beveled off from one side to the other to give a gradual sloping cutting action, the pressure required is much less than given in the table, and may usually be taken at one-half of the pressures for flat tools for stock not over, say, $\frac{1}{4}$-inch thick. Beyond that a safer amount would be two-thirds of the pressure necessary for dies without shear.

The action of the sheared face punch has been referred to in connection with Fig. 7 in Chapter I. Blanking punches of considerable length of cut are often finished along the face at an angle as indicated in Fig. 38 to provide the easy cutting action desired. And sometimes for the same purpose the face of the die itself is finished at an angle and the punch left square on the cutting edge.

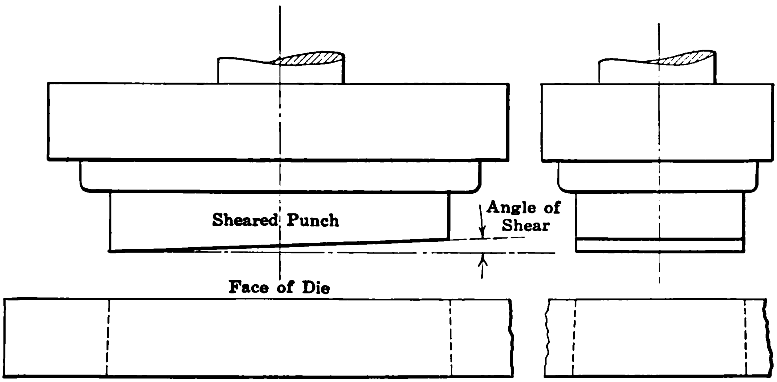


Fig. 38. — A sheared punch

Position of Blank Opening in the Die

Reference has been made at an earlier point in this chapter to the location of blanking die openings in relation to the edge of the die. Or, it might be better to say, in respect to the longitudinal center line of the die.

The shape and size of the blank are the determining factors by which the location of the die opening is fixed. If the blank is a simple straight piece and not unduly long, it may be located squarely in the die either lengthwise or crosswise according to the width of stock it may be desired to use, or to which arrangement will be most advantageous when the feeding of the stock and the operation of the stock stop are taken into consideration.

It is very often the case that the blank is of irregular form and of such outline that if placed directly lengthwise or crosswise of the die it would result in a great waste of material, owing to the area of metal that would lie between portions of the blanked openings in the strip as it was fed through. In such cases it is usually possible to locate the die opening at such an angle as to allow projections to overlap one another or to nest in together in such manner as to eliminate to a great extent the waste of material that would otherwise occur. Or, where this is not feasible the same economy in stock is effected by so arranging the dies and selecting the width of strip material as to allow the stock to be fed through once to allow the blanks to be produced from one side of the strip and then turning it over for a second passage through the dies in which another row of blanks

are cut out with their contours interlocking closely with the blanked openings formed in the first passage of the strip through the machine.

Besides the actual economy in material that is brought about by judicious arrangement of the dies relative to the center line or line of stock feed, it is generally possible to keep down to a reasonable number the different widths of strip stock carried in the press room rack, by so laying out new dies as to make use of some standard material always carried on hand. This oftentimes means that the punch and die will be made with their center lines at an angle greater or less with the body of the die so that the work will be blanked out obliquely to the edge of the strip of metal.

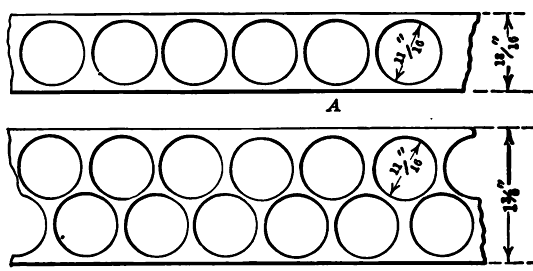


FIG. 39.—Two methods of locating blanks in the stock

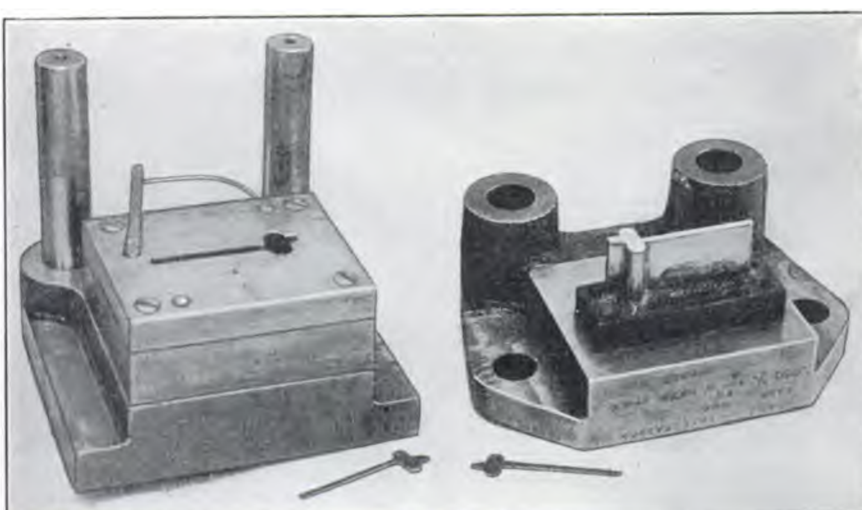


FIG. 40. — Die for a slender blank

SOME EXAMPLES

It is apparent that even with simple forms of blanks such, for example, as small gears or plain disks, there is an important saving in material by selecting stock of sufficient width to permit two or more rows of blanks to be made from the same strip. Thus taking the illustration in Fig. 39 which shows a strip of stock from which $\frac{13}{16}$-inch disks are blanked in a

single row as at A, and a wider strip for two rows at B. By locating the blanks in staggered position the wider strip enables two rows to be produced in a width $\frac{1}{4}$-inch narrower than the combined width of two single strips like the narrow one at A. And a still wider strip for three rows of blanks would be even more effective from the point of view of stock economy.

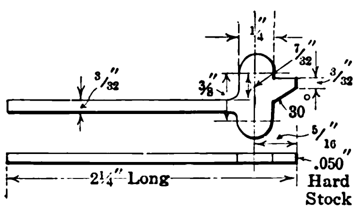


FIG. 41. — The blank

Some illustrations of blanking dies with the work done in various positions in respect to the center line of the die are shown in the views that follow: In Fig. 40, for

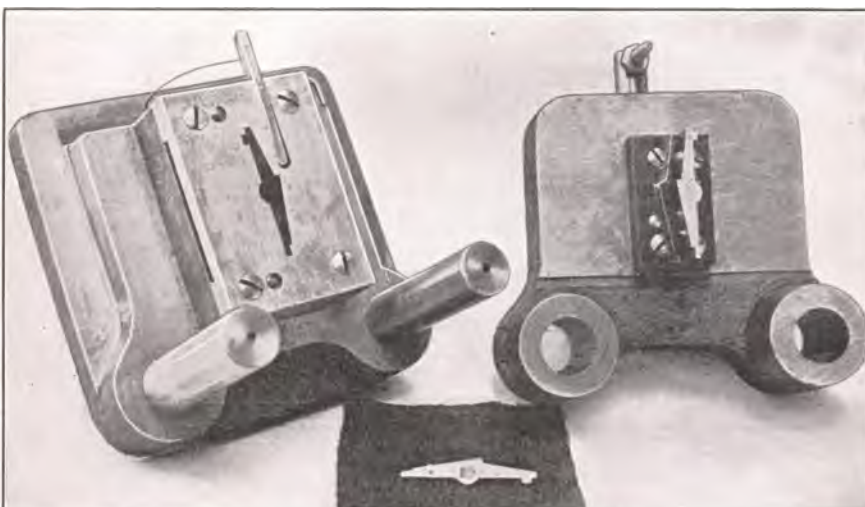


FIG. 42. — A rocker arm blanking die

example, is a set of blanking tools for making a long slender bar, Fig. 41, carrying a clover leaf form of head, the piece measuring about $2\frac{1}{4}$ inches long over all and the body being only $\frac{3}{32}$-inch wide. The die opening is parallel to the center and the stock stop is seated in the stripper at an angle to clear the fillister head screw at the side.

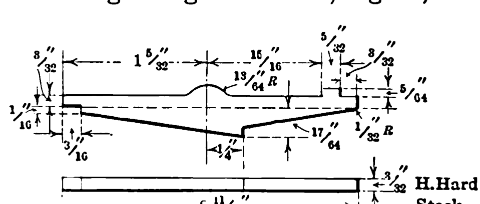


FIG. 43. — Rocker arm blank

The blanking die for the piece in Figs. 42 and 43 is made to cut out the work at right angles to the length of stock or 90 degrees around from the position of the die opening in Fig. 40. The dies in Fig. 44 are also made to blank the work, Fig. 45, crosswise of the stock and here is another good

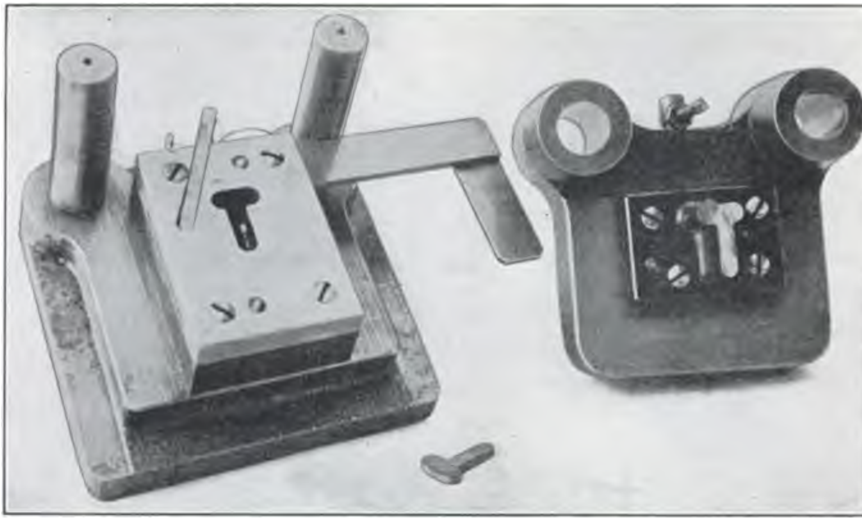


FIG. 44. — Blanking dies for a thick piece

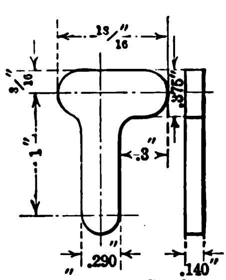


FIG. 45. — A three lobe blank

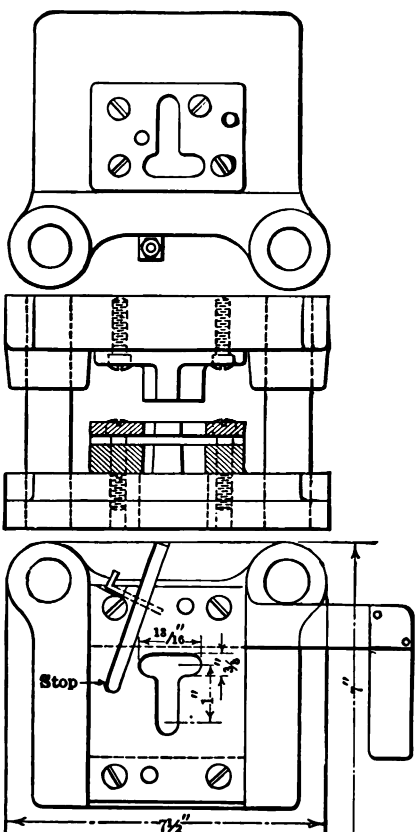


FIG. 46. — Details of dies for blank in Fig. 45

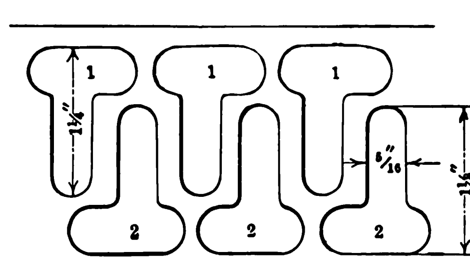


FIG. 47. — Blanking in double run through the press

illustration of the advantages in using wider stock than necessary for a single row of blanks and then reversing the strip of metal and running it through for the blanking out of a second row of parts. The construction of this set of blanking tools is shown in Fig. 46.

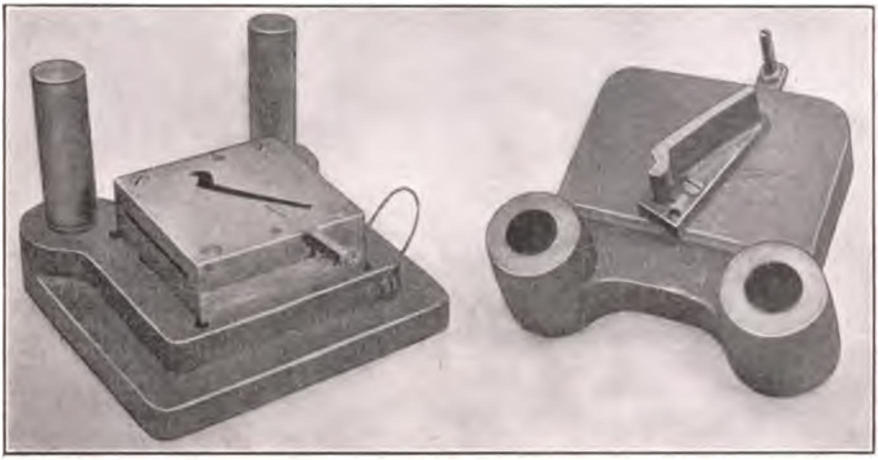


FIG. 48. — Dies made with diagonally placed opening

RELATIVE POSITIONS OF BLANKS

The sketch, Fig. 47, shows the manner in which the blanks in the first row, 1, 1, 1, are spaced, and how the second series indicated by numerals, 2, 2, 2, come midway of the openings from the first operation when the stock

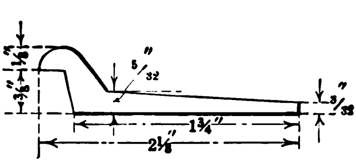


FIG. 49. — Another form of blank

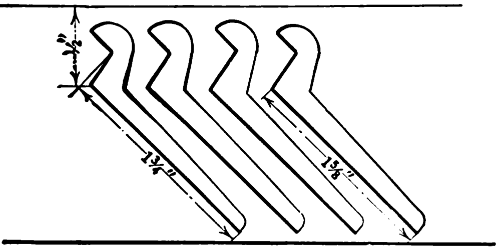


FIG. 50. — Work blank at an angle to edge of stock

is fed through on its second round. It may be noticed incidentally that these blanks are from what may be considered quite heavy gage stock for the small over-all dimension.

Here again the stock stop is located in an angular position to enable the contact end to be placed at the required point and the body to clear the screws and dowels in the die.

This die has an extension stock guide and support at the right which

is especially useful when feeding a strip through that has already been punched out for one row of blanks.

Another die, with oblique position of opening to blank the work at an angle to the edge of the stock, is seen in Fig. 48, the blank in Fig. 49 and the manner in which the blanks are spaced in Fig. 50. Here is a case where the die and punch are made at an angle to blank the work along closely parallel lines with a minimum of waste between successive blanks. The stock required for blanks thrown around in this way is also much less in width than would otherwise be necessary.

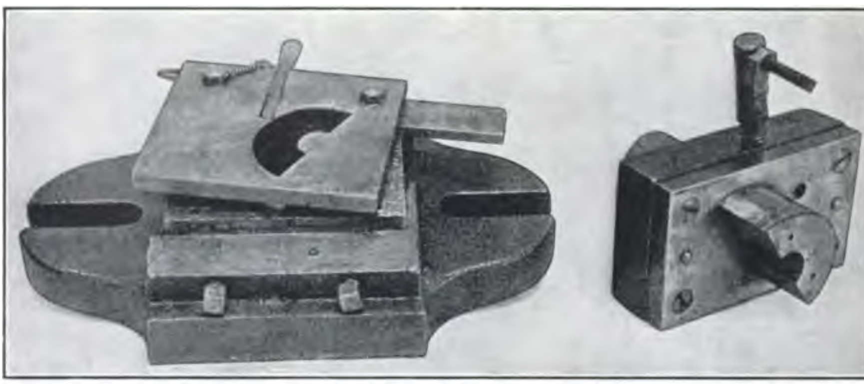


FIG. 51. — An open blanking set

The open blanking dies in Fig. 51 are likewise made to produce the work at a decided angle to the line of stock feed, for reasons similar to those already explained. This blank is semi-circular, $2\frac{1}{4}$-inch in diameter, and $\frac{7}{8}$-inch across the hole.

The line drawings, Figs. 52 to 64 inclusive, show further illustrations of strips of stock from which various shapes of blanks of different sizes have been punched. In a number of cases these blanks will be seen to have been made by running the stock through twice, and in these instances the blank positions for the first run are indicated by the numeral 1 and those of the second run are marked 2.

The illustration in Fig. 52 shows the placing of the blanks as produced by the dies, Fig. 40.

In all cases referred to a few dimensions are given approximately to convey an idea of the general proportions of the work.

These views are presented as of value in suggesting different ways in which such work may be blanked out of the stock to advantage.

A number of the dies thus far illustrated will be recognized as the tools used in blanking various pieces shown in the group in Fig. 29, which are a few parts for the Marchant Calculating Machine.

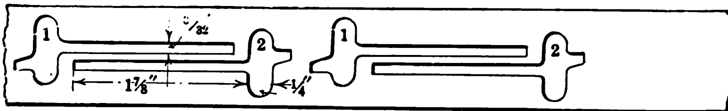


Fig. 52

Fig. 53

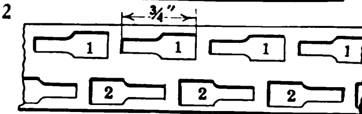


Fig. 54

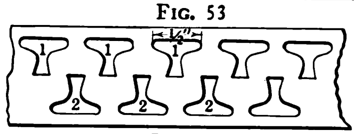


Fig. 55

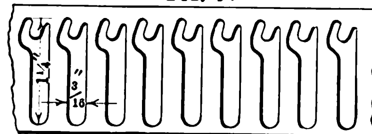


Fig. 56

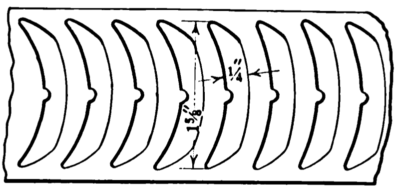


Fig. 57

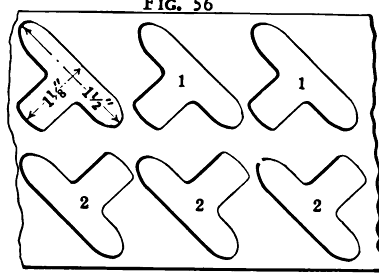


Fig. 58

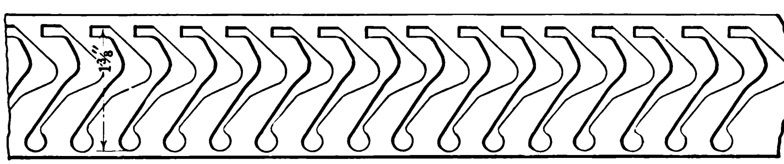
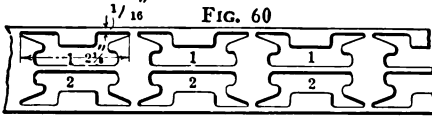


Fig. 59

Figs 52–59. — Various methods of locating blanks in stock

Fig. 60



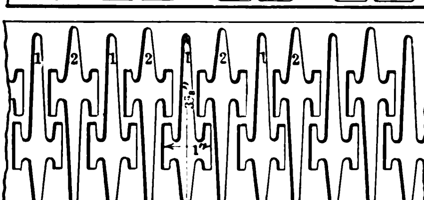


Fig. 61 (Interlocking) 2 Rows

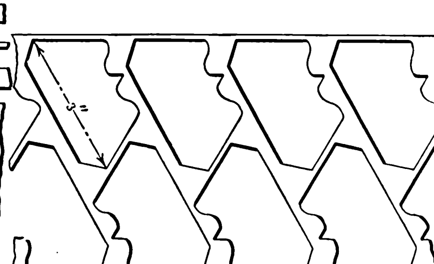


Fig. 62

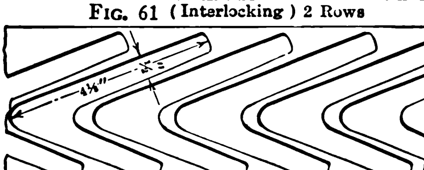


Fig. 63

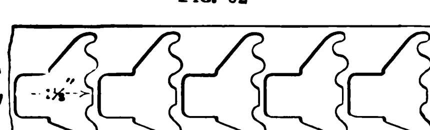


Fig. 64

Figs. 60–64. — Methods of locating blanks

Amount of Stock Between Adjacent Blanks

The amount of metal to leave between adjacent blanks in the strip of material is dependent in a measure upon the thickness of the stock and also upon the size and form of the blank. As a rule a minimum of $\frac{1}{16}$ inch is considered good practice for metal up to $\frac{1}{16}$-inch thick. From that thickness on up to $\frac{1}{8}$ inch it is preferable to leave from $\frac{3}{32}$ to $\frac{1}{8}$ inch.

There are cases where thin metal has been blanked with considerably less stock wasted between blanks than the $\frac{1}{16}$ inch referred to. But with many shapes of dies and with certain conditions of cutting edges there is always a possibility that the narrow bar of metal at the ends or sides of the blank may "draw" or pull into the die and result in unsatisfactory operation all the way round.

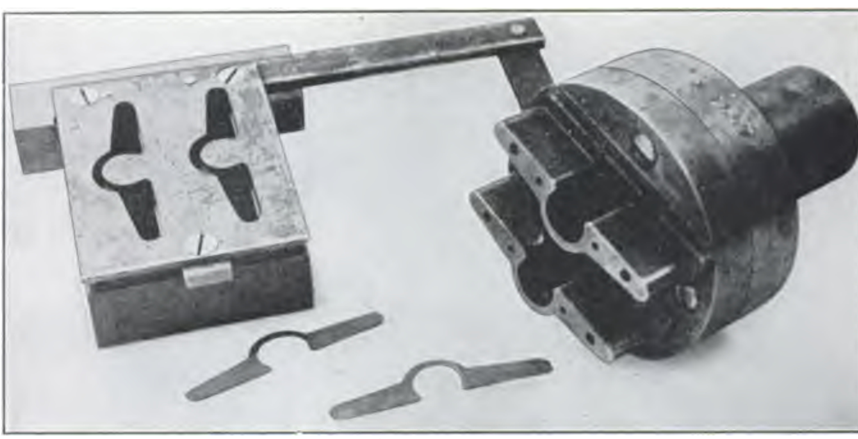


Fig. 65. — Double blanking tools

Moreover, the position and shape of stop used is sometimes a factor in fixing the allowance of stock between blanks at a reasonable amount that will not become distorted and unsatisfactory if used as a gage point for feeding against the stop.

Gang Tools

Blanking tools, like piercing dies, are often made up two, three or more in a gang to blank out as many pieces simultaneously.

A simple blanking set of this character is shown by Fig. 65 herewith. This is an open type of die with provision for producing two blanks at once. The work is a thin metal shim about $3\frac{1}{2}$ inches long. It is made in large quantities and the duplex type of die is, therefore, an aid to rapid production.

The die is made in a solid piece worked out in the usual fashion; the punches are made separately and are secured to the punch holder by screws

and dowels in the manner indicated. The spacing between the two dies is sufficient to leave a strong wall of metal and there is enough stock left between each pair of openings formed in the strip of metal as fed through so that it is again passed through the dies for blanking out a second lot of shims between the gaps left by the first blanking run.

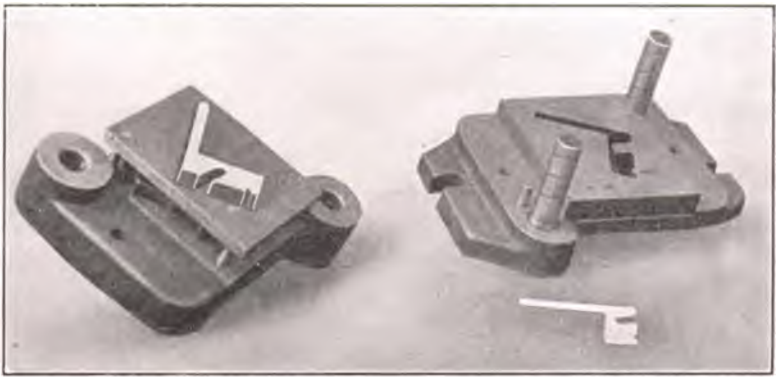


FIG. 66. — Blanking dies with pressure pad and stripper

FIG. 67. — Another blanking die with combined pressure pad and close fitting stripper

TWO OTHER BLANKING DIES FOR THIN WORK

Two sets of tools for parts somewhat similar to the work in Fig. 65 are shown in Figs. 66 and 67, these being made for blanking two pieces that are very much alike. The two dies are, however, directly opposite one another in arrangement. Each has its advantages. Both sets of tools blank out work three or four inches long on a side by $\frac{3}{4}$ to 1 inch wide and only 0.003 or 0.004 inch thick. In some cases the material is brass and in any event the stock is so thin in proportion to its area that special provision is necessary in the tools to produce blanks that will not be wrinkled on the surface or torn and rough along the edges.

Now we have in connection with drawing dies a feature known as a pressure pad whose purpose is the holding of the sheet metal under a definite degree of pressure while the operation of drawing is going on. This is to prevent wrinkling of the work and has the effect of ironing out the sheet metal as it is drawn down into the die from between the pressure pad and the upper face of the die.

Combined Pad and Stripper

A similar pressure pad may be employed to advantage in the construction of blanking dies like those in Figs. 66 and 67, only in these instances the pressure pad also combines with it the features of a close-fitting stripper, to clear the scrap from the punch.

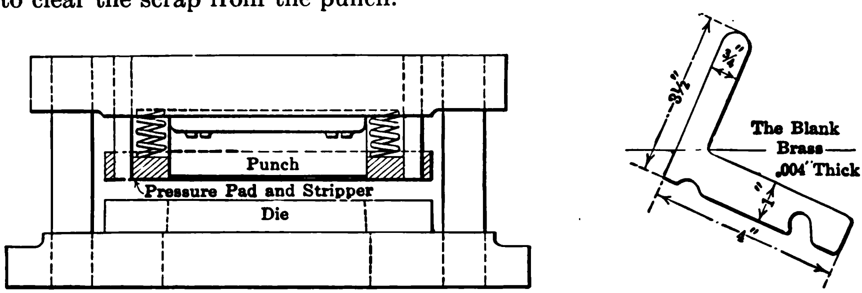


Fig. 68. — Construction of dies in Fig. 66

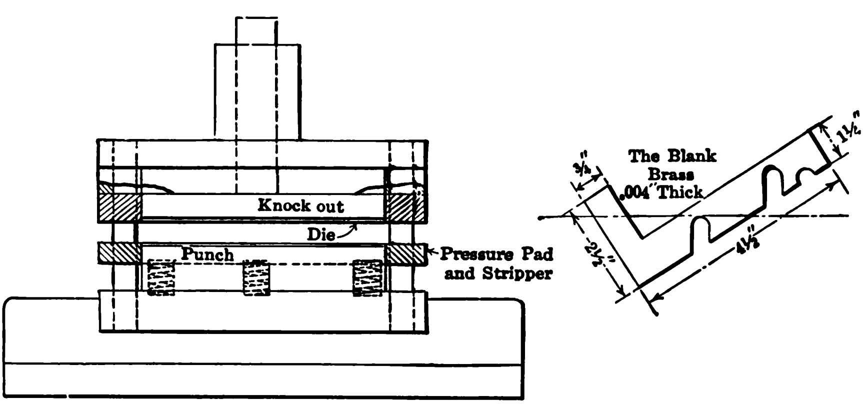


Fig. 69. — Construction of dies in Fig. 67

Both dies shown are of the sub-pressed or pillar type and the essential features of each are shown in Figs. 68 and 69, respectively.

Considering first the tools in Figs. 66 and 68, it may be stated that the stripper, instead of being carried by the die in the customary fashion for blanking operations, is here a part of the punch equipment, and mounted in the manner shown, it is held down by a series of stiff springs which, when the press slide descends, presses the thin sheet stock firmly against the

upper face of the die and holds it against possibility of movement while the punch cuts out the blank. Upon the upstroke, the pressure pad acts as a close fitting stripper, which prevents the stock from lifting with the punch and keeps it well flattened out until the end of the punch is clear of the work.

The Inverted Type of Die

Referring now to the other construction, Figs. 67 and 69, it will be seen that the die is inverted and carried as the upper member of the set while the punch occupies the position below, usually the place of the die.

Here again the combined pressure pad and close-fitting stripper are carried by the punch with a set of heavy springs beneath to keep the face of the pad against the lower face of the die when the latter is carried downward by the press slide. As the die cuts out the blank by forcing the stock down over the inverted punch, the pressure pad maintains a firm degree of pressure upon the stock and allows the thin blank to be produced without wrinkling or distortion.

Upon the return stroke of the press slide, the pressure pad acting now as a close-fitting stripper lifts the strip of stock to the top of the punch and the knock-out carried in the die above ejects the thin blank from the die.

Relative Advantages

There are advantages connected with each arrangement of blanking tools for thin work of the character described. The construction in Figs. 66 and 68 is the more common, for it is somewhat simpler and less expensive to make. It has the disadvantage for very thin stock that the blanks as forced down through the die openings may become clogged and more or less distorted in their passage out of the press. Sometimes, however, this type of die is fitted with an ejector or knock-out that lifts the blank back into the strip of metal, where it is carried out of the press by the advancing movement of the stock through the dies.

With the inverted form of construction shown in Figs. 67 and 69, both stock and blank are kept straightened out at all times, there is no opportunity for the blank to become injured in the dies as it is ejected back onto the strip by the action of the knock-out above, and the edges of both punch and die are kept clear of chips or fine particles of metal by the operation of the stripper and ejector.

Large Blanking Tools

Press working operations are nowadays extended to include the manufacture of very large work, sometimes measuring up to several feet in length or diameter. The illustrations that follow here are not by any means of the largest sizes of blanking dies made but they show at least typical equip-

ment for blanking medium size pieces and parts that for the average shop would be considered fairly big work.

The half-tones, Figs. 70 and 71, represent blanking tools for electric motor disks, the first illustration showing dies for circular work of about

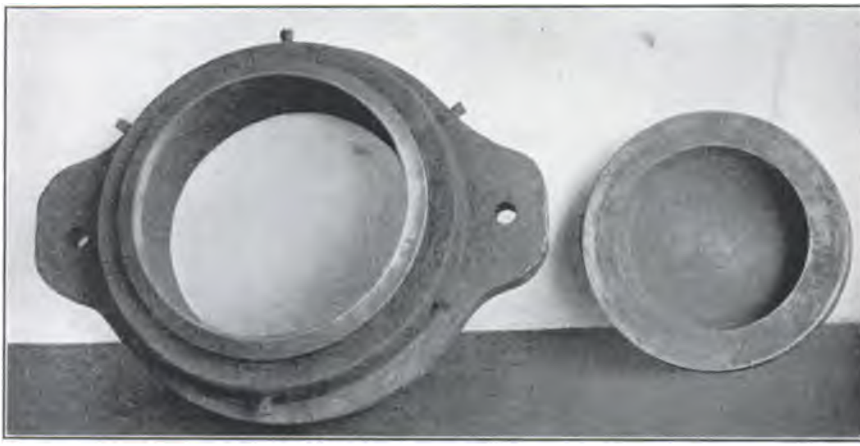


Fig. 70. — Dies for 12″ motor blanks

Fig. 71. — Tooth for blanking out an 8″ center from a disk

12 inches diameter. Such tools are made in similar form for plain disks of the same type of much larger dimensions.

The die is in the form of a cast iron base with a steel cutting ring inserted and secured in the manner plainly shown. This ring is about $\frac{3}{4}$ inch thick and about $1\frac{1}{2}$ inch deep. It is fitted into a counterbored seat in the

interior of the cast iron die block and its upper face is beveled at an acute angle to leave a land at the top of $\frac{1}{8}$ inch or so which is readily ground when the die requires sharpening.

The punch is of similar construction with a steel ring secured to the outer end of a cast disk acting as a holder.

Internal Blanking Tools

In connection with electrical and similar work there are many parts that have to be manufactured in the form of rings with a large center cut out and the blank thus removed is utilized for smaller sizes of disks and

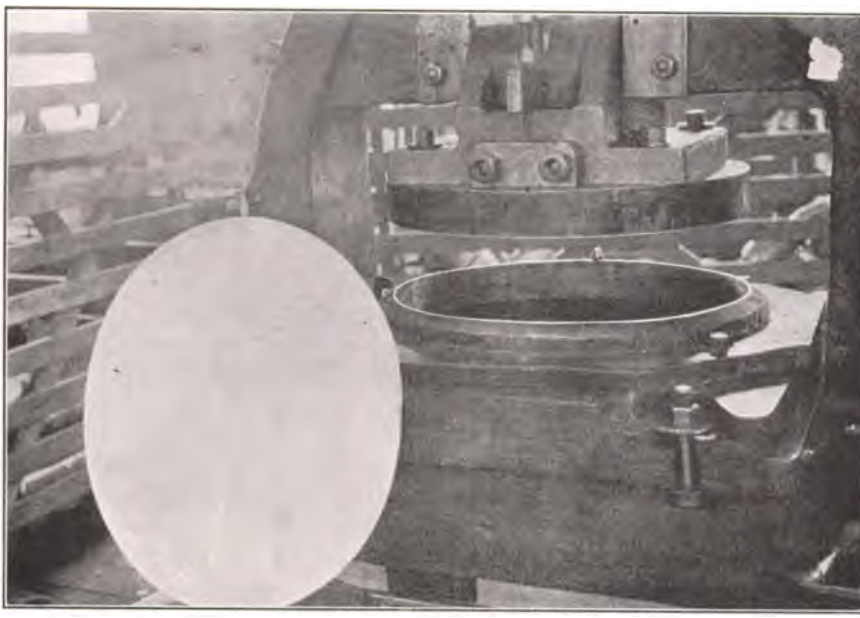


Fig. 72. — Blanking dies for a 24 inch oval

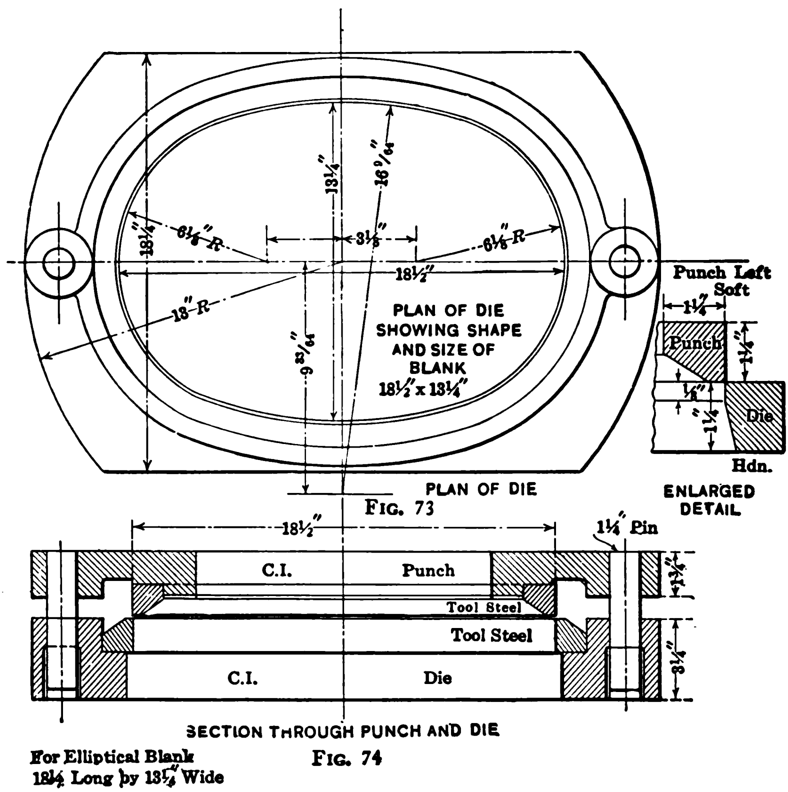
rings. A typical instance is shown in Fig. 71. The outer edge of the big blank to the left has been notched previously to being blanked out inside, and the tools here represented are for the latter operation.

For this second blanking cut, the disk is located or nested on the die by a series of pins spaced about its edge which enter the notches already referred to. The die is made up in the same manner as the one just described and its cutting ring is provided with the same beveled face and narrow working edge. The blanking punch is formed, as in the case of the first one noted, with a steel ring on a cast center.

Large Oval Die

Usually dies of large diameter blank their work from a sheet of approximate size instead of from a long strip. Sometimes the sheet is trimmed beforehand to form a convenient size for handling in the press and to enable it to be located against stop pins near the mouth of the die.

In the manufacture of sheet metal ware, such as aluminum utensils, there are many examples of large press work seldom seen elsewhere. The



Figs. 73–74. — Large elliptical dies

view in Fig. 72, for instance, represents the blanking of an oval in aluminum which is later to be drawn up into a shallow pan. This blank is about two feet long. The tools are shown in the press and their construction is so clear as to require little description.

The stops for locating the aluminum sheet are seen at the rear and ends of the die, where they are so placed that there is little metal left at the edges of the scrap sheet when the blank is made.

Another Elliptical Die

A large oval die shown in plan and section in Figs. 73 and 74 is for blanking black iron work of No. 28, 29, and 30 Birmingham gage, or 0.012 to 0.014 inch thick. The length of the piece is $18\frac{1}{2}$ inches. The tools are of the pillar type and the cutting portions are tool steel rings fixed to cast iron bases, the punch ring being shrunk into place and the die pressed into its seat.

The die is hardened but the punch is left soft so that when it becomes worn it may be upset slightly and resized. This is a feature sometimes adopted with small tools as well, so that the punch size may be maintained closely to the original size of the die, or if desired upset to a slightly larger dimension than when first made, in order to compensate for slight increase in the die as the latter becomes enlarged through wear and because of the

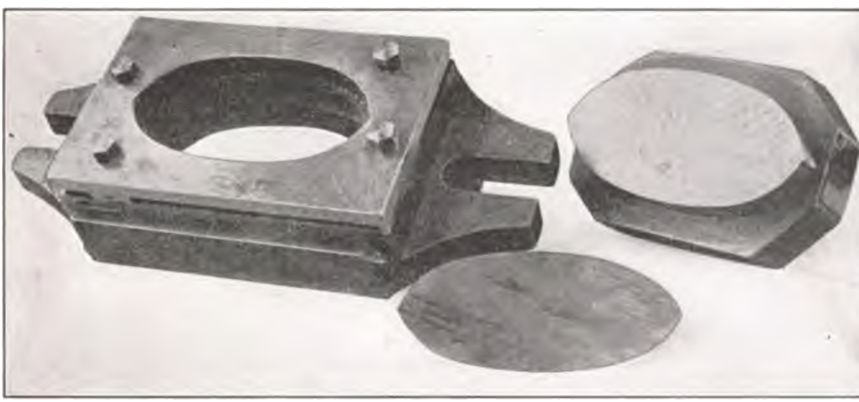


Fig. 75. — Sectional dies made in halves

tapered interior which increases the die size slightly as the top is ground off by repeated resharpening.

The die shown, however, is straight for a depth of $\frac{1}{8}$ inch and relieved only below that point. So it retains its original dimensions until such time as the full eighth inch has been ground down.

Details of Punch and Guide Pins

The metal to be blanked being very thin for this size of work, the punch is made a fairly close fit to the die. The pillars or guide pins are reversed from the usual order, in that they are fixed in the punch holder and slide in the die base holes. This arrangement is necessary on account of the large area of the press ram which prevents the pins from rising above the top of the die.

It will be noticed that the tops of the guide bosses on the die are practi-

cally flush with the face of the die. This insures a steadiness of action that is not usually obtainable with big dies of this kind where the bosses referred to are lower than the die face. With the cutting edge of the die and the face of the guides in the same plane the guide pins have a smooth

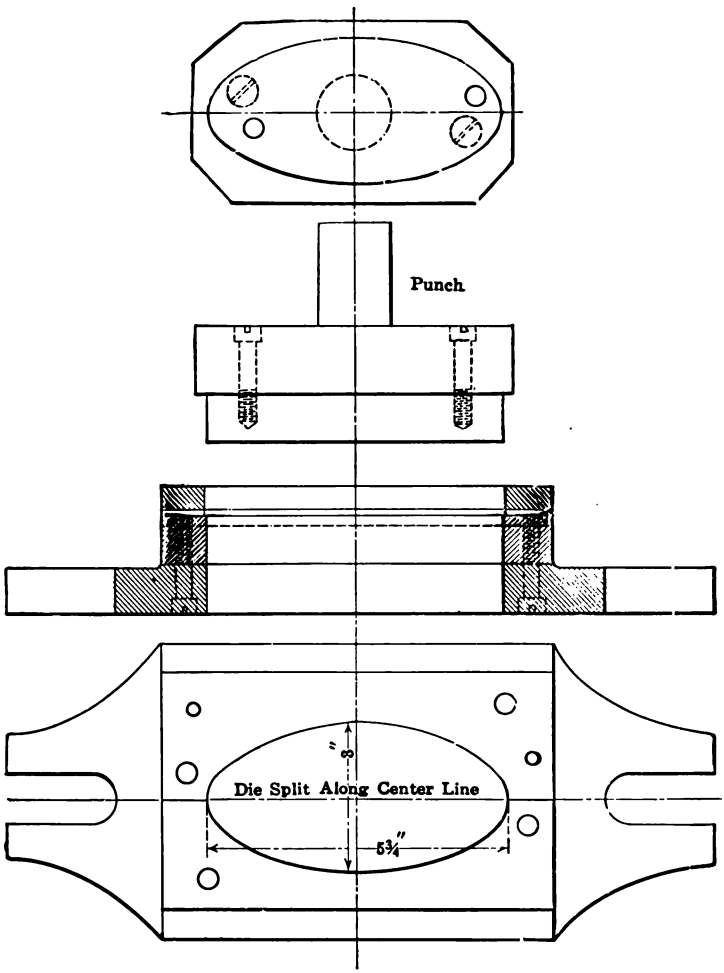


Fig. 76. — Layout of split die

movement without liability of cramping action and consequent shearing and injury of the dies.

In spite of the fact that the punch is left without being hardened, its wear is negligible for a long period. The die proper although blanking black stock with more or less scale on its surface will run fully 10,000 blanks before it requires grinding.

Sectional Constructions

The sectional construction for punches and dies permits many advantages to be derived in connection with the making and upkeep of the tools. While this type of construction is a great aid in the making of large dies, it is also extremely useful in the cases of numerous classes of medium sized and fairly small tools, for it enables many awkward forms of dies to be made accurately without serious complications in respect to the tool room methods of handling, where with a solid form of die certain portions of the work would be well-nigh impossible of making up without a very great amount of tedious labor, much of it carried out by hand processes entirely.

The sectional die allows the tool maker to avoid the necessity of working out various odd corners, awkward angles, and the like and when the die is once completed if it later becomes necessary to repair some portion of it the

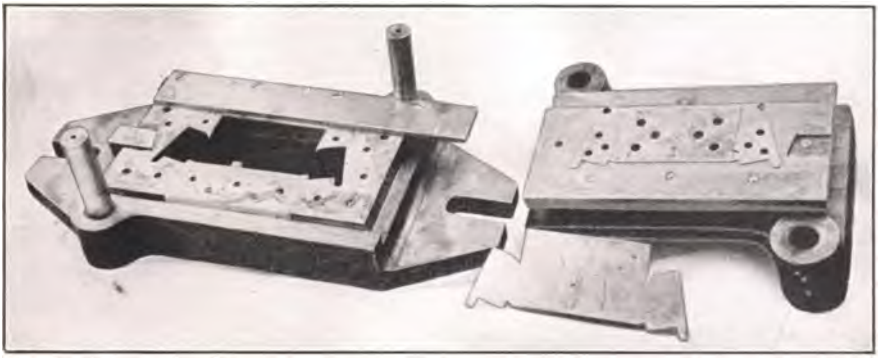


Fig. 77. — Another sectional die

entire tool is not affected to the extent of requiring replacement. The problem of hardening and tempering is also simplified and dies of such size and form that they could hardly be hardened satisfactorily at all, if made in a single piece, are under the sectional construction put through the above processes without difficulty.

A Die in Halves

The simplest form of a sectional die, a split design, is represented by Figs. 75 and 76. This die is for blanking an oval or ellipitical piece in brass of a length of $5\frac{3}{4}$ inches and a width of 3 inches. The blank is shown at the front of the die in the half-tone. The manner of dividing the die on the center line is best brought out by the drawing, Fig. 76.

The plan view here shows the positions of the die sections with each balf secured by fillister head screws and dowels. The two parts being

symmetrical about the center line it is possible to work them out together so far as the main machine operations are concerned and in case of distortion in the hardening operation the individual halves admit of convenient correction by grinding and lapping and the abutting joints may be lapped down if necessary to correct the shorter diameter or minor axis. Also wear may sometimes be compensated for in sectional dies by taking apart and grinding off the face of the joints and reassembling.

Dies with Several Sections

The sectional tools in Fig. 77 are for blanking a piece that is afterward formed up into a cover for a machine mechanism. There are a number of sharp corners in the die and several delicate, sharply pointed projections

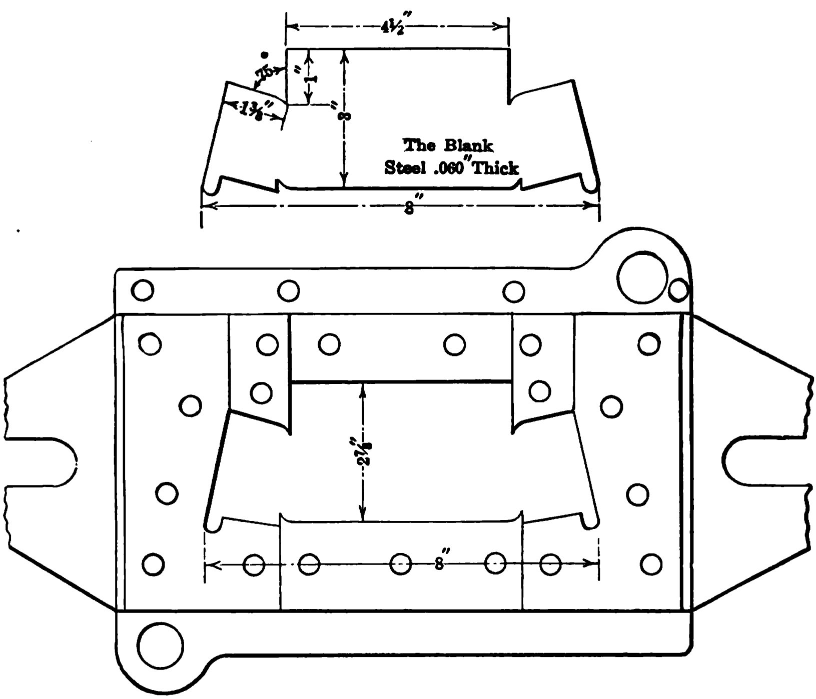


Fig. 78. — Construction of die in Fig. 77

The blank is 8 inches long over the outer corners and $2\frac{7}{8}$ inches across at the widest point.

The die was laid out in the sectional form shown best in Fig. 78 where, as will be noted, the different parts assume a much simpler outline than would at first appear to be possible. One section is a straight, parallel piece and three others are almost as simple except for the sloping ends and the curved points in which they terminate.

Here again several of the members may be laid out and developed into pairs. The machining and finishing must of course be done with a knowledge of the change in dimensions likely to occur when the parts are hardened and corresponding allowance can then be made for correction if necessary before assembling.

With such dies it is customary in some places to leave all members purposely two or three-thousandths long and wide and then finish by grinding and lapping after the hardening and drawing have been attended to. So, if the characteristics of the particular tool steel used have not been thoroughly understood or if the heating and tempering of the sections have not been accomplished with a negligible amount of change in the dimensions of the different parts, very accurate results will still be assured by the grinding and lapping of the abutting surfaces.

The foregoing examples of blanking dies and the data pertaining to them in this chapter have been rather closely restricted to such tools for blanking alone, without taking into consideration the innumerable cases where they are combined or "doubled up" with other dies for piercing and blanking, blanking and drawing, blanking and forming and so on. Many illustrations of their application in this manner will be presented in chapters that follow. Also under special chapter heads will be found a number of complete sets of dies where the work starts with the operation in the blanking die and is then carried successively through a series of other press tools until it is completed. These various chapters will therefore cover many forms and uses of the blanking die which are not described in the present chapter.

CHAPTER III

PIERCING TOOLS — BLANKING AND PIERCING DIES

A number of pieces representing certain classes of press work as pierced in separate dies or pierced and blanked in a set of progressive tools accomplishing both operations are illustrated in Fig. 79. Some of the examples in the group will be seen to be duplicates of those shown in Fig.

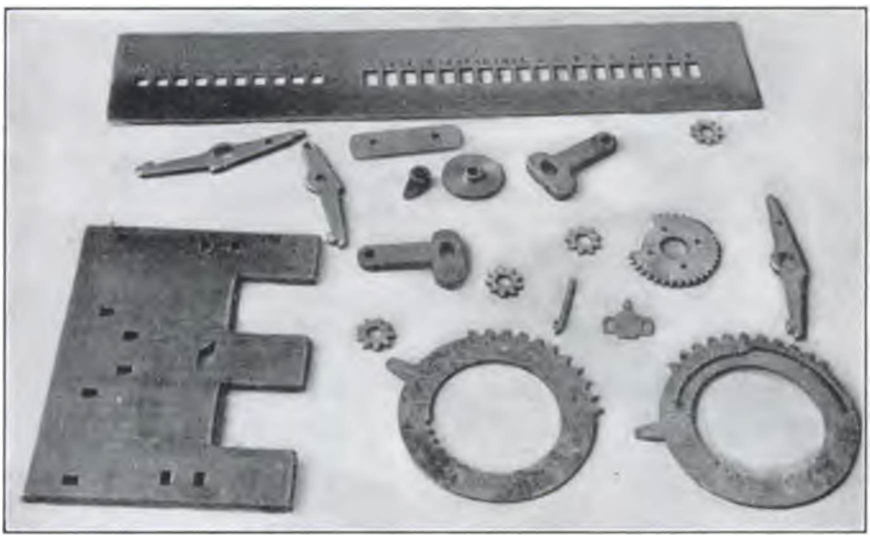


FIG. 79. — Examples of blanked and pierced work

35, but here they have been advanced through another operation, namely piercing.

PUNCH DIES

The simplest form of piercing die and presumably the first form ever made is what is generally known as the "punch die" so commonly used on boiler plate and other sheet metal up to very thick plates preliminary to riveting. A simple set of tools of this general character are shown by Fig. 80. Often the dies are inserted in long bed plates and a row of punches secured in similar types of holders are used for punching a series of holes at once in the edge of a plate.

Dies of this kind are not precision tools in the usual sense of the word, but they are so generally required in certain lines of work that a few particulars regarding their construction may well be included in this chapter.

The punch die proper is usually a round-bodied tool as in Fig. 81 adapted for setting in a circular seat in its block and made with a beveled top face

FIG. 80. — Simple piercing tools

to aid in the piercing out of the hole upon the descent of the punch. The punch may be either flat ended or with a spiral sheared end which gives a free action and requires less power for the performance of the work. A spiral form of punch is shown by Fig. 82, the flat end punch by. Fig. 83.

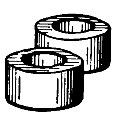


FIG. 81

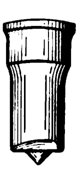


FIG. 82

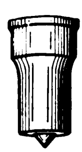


FIG. 83

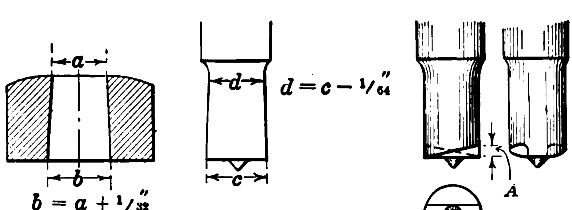


FIG. 84

FIGS. 81–84. — Punch dies for plate work

The practice of one of our best-known railroad shop tool rooms in respect to such dies should be of value here as shops of this kind make very wide use of punch dies in their plate departments. It is the practice in the shop referred to to make the dies with $\frac{1}{32}$ inch inside taper or clearance and to give the punch one-half that amount of taper back from the cutting end, or $\frac{1}{64}$ inch as in the sketch, Fig. 84. These clearances apply to a one-inch size of die. For smaller dies, say $\frac{1}{4}$ inch, the die has an inside taper of $\frac{1}{64}$ inch and the punch is cleared back from the end one-half that amount. A proportionate amount of taper is maintained for the intermediate sizes.

The spiral shear on the end of the punch is given at A as $\frac{3}{16}$ inch for $1\frac{7}{16}$-

inch punches, $\frac{1}{8}$ inch for 1-inch punches, $\frac{3}{32}$ inch for $\frac{3}{4}$-inch punches, and below that the flat end punch is used. The spiral punches are usually employed for plate up to a thickness equal to the diameter of the punch. For plates less than about $\frac{3}{8}$ or $\frac{1}{2}$ inch the punches are left flat.

Life of Tools

There is a considerable amount of clearance between the diameter of punch and die which may be stated to be as follows: For sizes up to $1\frac{1}{2}$ inches allow $\frac{1}{32}$ inch between punch and die size. It is common practice to make the die $\frac{1}{64}$ above and the punch $\frac{1}{64}$ inch below nominal size for the general run of work of this kind. In ordinary practice the die will outlast a number of punches, perhaps ten or more. If starting in at a die thickness of say $1\frac{1}{8}$ inch it will be ground down to $\frac{3}{4}$ inch before discarding for the original size of hole and then it is ground out in the hole for the next larger size of work. Although such dies are used in the most severe service they are often run for several thousand holes before the tools require resharpening.

Obviously the holes punched are allowed a little more latitude as to size than is permissible with the usual run of press work. To begin with a punch for a $\frac{1}{4}$-inch rivet will have a diameter about 0.030 larger than the nominal rivet size and for a 1-inch rivet the punch will be twice that amount larger or 0.060 inch over the nominal diameter of the rivet. The practice of the Pratt & Whitney Company in this respect is covered in the accompanying Table No. 4 which gives the size of punches as made by that firm for all sizes of rivets from $\frac{3}{16}$ up to 1 inch.

TABLE 4. — PUNCH SIZES FOR RIVETS FROM $\frac{3}{16}$ TO 1 INCH DIAMETER

Size of rivet.	Size of punch	Size of rivet	Size of punch
Inch	Inch	Inch	Inch
$\frac{3}{16}$	0.210	$\frac{5}{8}$	0.690
$\frac{1}{4}$	0.280	$\frac{11}{16}$	0.740
$\frac{5}{16}$	0.340	$\frac{3}{4}$	0.800
$\frac{3}{8}$	0.410	$\frac{13}{16}$	0.860
$\frac{7}{16}$	0.470	$\frac{7}{8}$	0.940
$\frac{1}{2}$	0.550	$\frac{15}{16}$	1.000
$\frac{9}{16}$	0.620	1	1.060

A Double Punch and Die

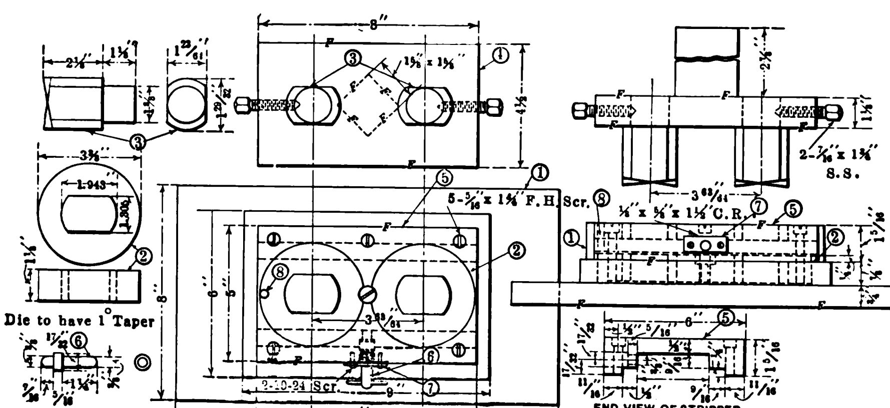
Another form of punch in which the sheared principle is applied is shown in Fig. 85, where the press tools are illustrated for making two rectangular holes in a steel link which is about 8 inches long over-all, the oblong holes pierced in it being 1.94 inch long by 1.365 inch wide. The

details of the tools are given in Fig. 86 to show the manner of inserting separate dies in the block and other features of interest.

The stock pierced with these tools is half-inch thick. The method of providing shear on the punches from opposite sides will be apparent from

FIG. 85. — Double tools for piercing a link

the photograph and drawing. There is in the long way of the punch an allowance of $\frac{1}{32}$ inch between the punch and die size, but in the width



No.	Description	No. Rec.	Material
1	Die Bed	1	M.S.
2	Blanking Die	2	T.S.
3	Blanking Pun.	2	T.S.
4	Punch Holder	1	M.S.
5	Stripper	1	M.S.
6	Guide Pin	1	T.S.
7	Guide Pin Plate	1	C.R.S.
8	Stop Pin	1	T.S.

FIG. 86. — Details of link piercing tools

there is less, or about 0.005 only, for the fit in that direction is more important owing to the parts that enter these link openings, and with the method of shearing the punch there is not so much likelihood of the punches throwing to one side sufficiently to shear the die.

Dies for Closer Work

Coming now to the class of piercing dies for the general run of press-room work where sheet metal of considerably lighter gage is commonly handled and where a close degree of accuracy is essential, it may be pointed out that the accuracy of results is dependent upon the punch which is made to the size of the hole which is required to be pierced, while the clearance is allowed in the die. It is recommended that for very close results the punch be made 0.001 to 0.002 inch larger than the size of the hole required because the tendency of the work is to hug the punch and when stripped off to close up slightly.

The allowances between punch and die for different gages of stock and for various kinds of metal may be taken the same as the clearances between blanking punches and dies as given in Table 2, Chapter II, this clearance depending upon the thickness of the stock and its character as to hardness, etc., and also upon the closeness of the results required. The table has been computed, as already explained, to cover a range of materials and requirements as to accuracy.

Table of Pressures for Piercing

Before entering into details of construction of various types of piercing tools a table of pressures required for different thicknesses and grades of stock may be of interest. Thus Table 5 has been worked out to cover the same gage numbers and materials as are included in Table 3 of shearing pressures in the chapter on Blanking Dies

Fig. 87. — Small piercing dies

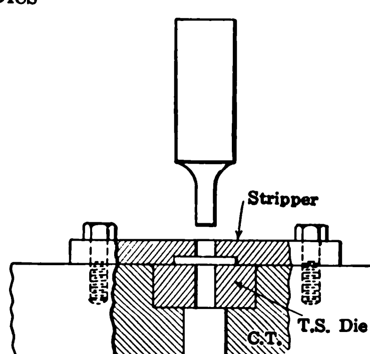


Fig. 88. — Section of piercing die

Simple Piercing Tools for Strip Metal

A simple form of open piercing die is shown by Fig. 87, this consisting of a plain die block, a round inserted die, and a stripper and guide for the stock.

The punch is a one-inch piece of steel turned at the end to the desired

TABLE 5.—APPROXIMATE PRESSURES IN POUNDS FOR PUNCHING BRASS AND STEEL; FOR 1-INCH DIAMETER OF HOLE

Gage U. S. standard plate		Shearing strength of brass per sq. in. = 35,000 lbs. Shearing strength of steel per sq. in. = 50,000 lbs. Shearing strength of high carbon steel per sq. in. = 75,000 lbs.		
No.	Thickness	Brass	Steel	High-carbon steel
28	0.015625	1,718	2,454	3,681
27	0.0171875	1,870	2,790	3,928
26	0.01875	2,067	2,940	4,395
25	0.021875	2,408	3,422	5,168
24	0.025	2,749	3,927	5,890
23	0.028125	3,080	4,396	6,640
22	0.03125	3,440	4,914	7,316
21	0.034875	3,781	5,385	8,024
20	0.0375	4,123	5,890	8,835
19	0.04375	4,816	6,876	10,484
18	0.05	5,498	7,854	11,781
17	0.05625	6,190	8,940	13,236
16	0.0625	6,872	9,817	14,726
15	0.0703125	7,696	10,990	16,520
14	0.078125	8,597	12,246	18,408
13	0.09375	10,335	14,765	22,148
12	0.109375	11,985	17,110	25,721
11	0.125	13,744	19,635	29,452
10	0.140625	15,505	22,135	33,040
9	0.15625	17,150	24,540	36,810
8	0.171875	18,912	27,900	39,280
7	0.1875	20,672	29,400	43,950
6	0.203125	22,321	31,870	47,900
5	0.21875	24,080	34,220	51,680
4	0.234375	25,729	36,700	55,224
3	0.250	27,490	39,270	58,900
2				
1				

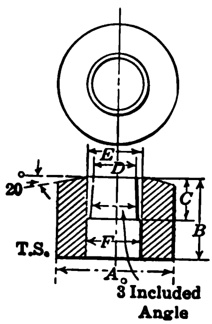
Rule: Multiply thickness of stock by length by shearing strength of material.

diameter for the hole to be pierced. The section through the dies is as indicated in Fig. 88.

Piercing dies are often required for punching a number of holes in a piece at once and sometimes the holes run up to a hundred or more, as when piercing fine openings in utensils of one kind or another. Such tools are called perforating dies. Where two or three or a dozen holes or so are punched simultaneously the tools used are generally known as gang dies, particularly when the holes are not very small in diameter. With fine punches, however, they are known as perforating tools.

Table 6 gives dimensions of a series of round or button dies with 3 degrees clearance inside, and with 20 degrees bevel at the top. The outside diameters are dimensioned 0.001 to 0.002 over size to allow for pressing into place in the die holder.

TABLE 6. — BUTTON DIES



D = diam. of hole in die	A	B	C	E	F
$\frac{3}{32}$ to $\frac{3}{16}$	0.626	$\frac{3}{4}$	$\frac{1}{4}$	$D+\frac{1}{8}$	$D+\frac{1}{32}$
$\frac{7}{32}$ to $\frac{5}{16}$	0.8135	$\frac{7}{8}$	$\frac{3}{8}$	$D+\frac{1}{8}$	$D+\frac{1}{32}$
$\frac{11}{32}$ to $\frac{1}{2}$	1.001	1	$\frac{3}{8}$	$D+\frac{1}{8}$	$D+\frac{1}{32}$
$\frac{17}{32}$ to $\frac{11}{16}$	1.252	1	$\frac{1}{2}$	$D+\frac{1}{8}$	$D+\frac{1}{32}$
$\frac{23}{32}$ to $\frac{7}{8}$	1.502	1	$\frac{1}{2}$	$D+\frac{1}{8}$	$D+\frac{1}{32}$

A PERFORATING DIE

An illustration of a perforating die with several hundred punches for piercing the minute holes in the bottom of a thin shell is given in Fig. 89. The punches are all of small drill rod inserted in a holder as in Fig. 90 and

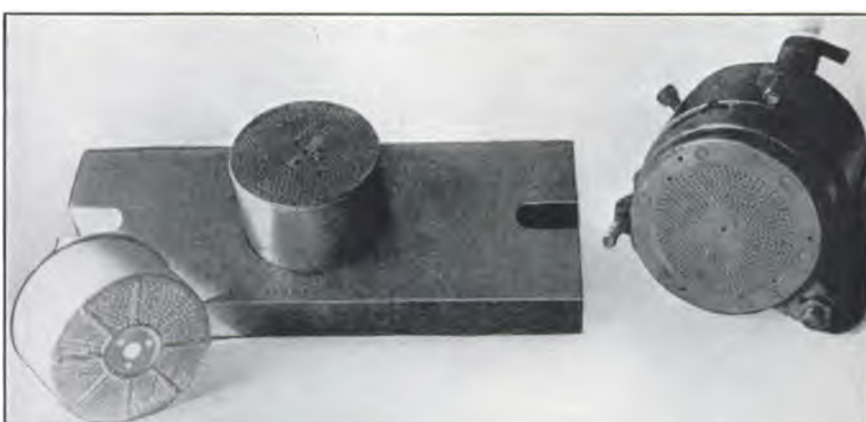


FIG. 89. — Perforating dies

fitting closely in the stripper plate to give them a support at their cutting ends. The die and stripper plate and holder are all drilled to match by using the plate as a jig. The construction shows an open form of die though a preferable design would be the subpressed type which assures

alinement of tools and prevents likelihood of the small punches being broken or the die injured. These tools are shown here, however, as an illustration of a simple means of perforating a large number of holes at once.

Internal Clearance in Piercing Dies

Piercing and perforating dies are cleared or tapered internally on the same principle as blanking dies but it is often desirable to give them a greater amount of clearance than the ½ degree on a side, so common with blanking dies, for the reason that the slugs punched out of the stock are apt to clog up in the dies and swage together, forming an obstruction to satisfactory operation and with the smaller sizes of tools leading often to broken punches and sheared dies.

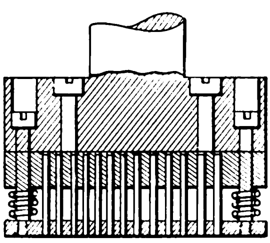


Fig. 90. — Section through perforating dies

This difficulty has already been referred to in connection with the table of die clearances in the preceding chapter and Table 1 in that section will therefore be of value as showing the actual clearances in thousandths represented by various side angles in degrees. The table referred to is computed for clearances up to 2½ degrees on a side.

The piercing die is often reamed out from the back with a standard taper pin reamer which gives a clearance of about 1¼ degrees. Then there are special die reamers or broaches so called which give an increased taper equal to 2½ to 3 degrees.

Multiple Tools

The gang dies or multiple dies in Fig. 91 are for piercing four ½-inch holes at once in ⅛-inch steel pieces which have been already formed to length. The method of inserting the punches will be of interest. These are made as at *A* of ¾-inch drill rod, turned down, hardened and ground, leaving a head at the end which enters a counterbore in the block *B*. The block is of machine steel, accurately bored for center distances and for the size of the punches and closely fitted in a seat planed in the punch holder proper *C*. The heads of the four punches abut against a hardened and ground steel plate *D* which is secured in the punch holder or head to receive the thrust of the punches. Three countersunk head screws hold the thrust plate in place and two fillister head screws secure the punch block *B*.

The stripper plate *E*, in this case, serves as a pressure pad and is carried by four long fillister head screws. The pressure behind this pad when the punch is down is maintained by a thick rubber pad at *F* which is used by many die makers in preference to a series of heavy springs.

The die *G* is a tool steel block bored accurately, and finished by grinding

after hardening, and fitted in its seat in the die block. Here it is secured by fillister head screws and dowels.

The tools are of the pillar or subpressed order with 1-inch posts or guide pins for preserving alinement. The plan view of the die shows the method of forming the seat for the four hole die block by making four corner holes

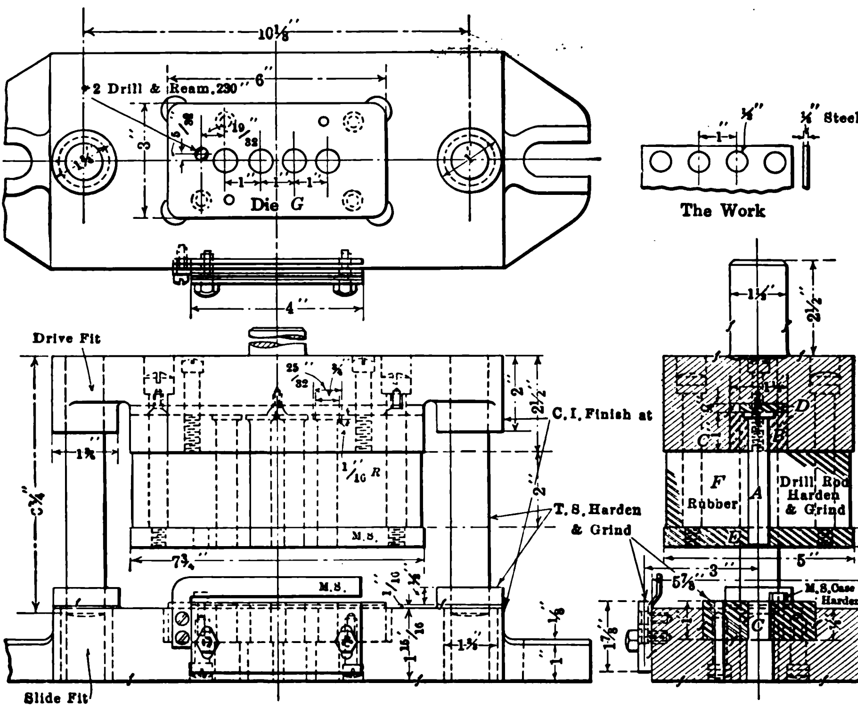


FIG. 91. — Gang piercing die

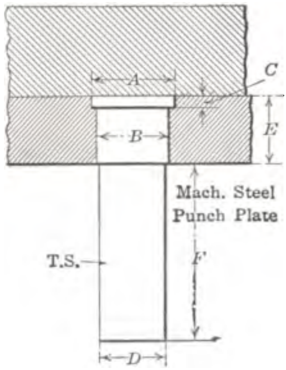
in the base for the clearance of the cuts and rounding the corners of die *G* to clear accordingly.

Table 7 covers a series of punches for various sizes of pierced holes. The punch bodies at a point immediately under the head are 0.001 inch large for fitting snugly in the punch plate as indicated. Such punches are readily ground to size and fitted to their places.

Bushed Dies

With gang dies it is often the practice to make the piercing dies in the form of bushings which can be readily fitted and replaced independently. This is of advantage particularly where there are quite a number of holes to be punched and where the arrangement of the die openings is not along a straight line as they were in the last illustration.

TABLE 7. — PIERCING PUNCHES



Diam. punch D	A	B	C	E	F
In.					
0–$\frac{1}{4}$	$\frac{5}{16}$	0.251	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{5}{16}$	$\frac{7}{16}$	0.3135	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{3}{8}$	$\frac{1}{2}$	0.376	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{7}{16}$	$\frac{9}{16}$	0.4385	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{1}{2}$	$\frac{5}{8}$	0.501	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{9}{16}$	$\frac{11}{16}$	0.5635	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{5}{8}$	$\frac{3}{4}$	0.626	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{11}{16}$	$\frac{13}{16}$	0.6885	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$
$\frac{3}{4}$	$\frac{7}{8}$	0.751	$\frac{3}{32}$	$\frac{5}{8}$	$1\frac{3}{4}$

In Fig. 92 a set of tools is shown for piercing a series of 40 holes in a circle of 8 in. diameter in a steel disk for electrical apparatus. The pierced disk is shown at the right in the view. The punches are inserted in similar fashion to those in Fig. 91 but the stripper plate is backed up by

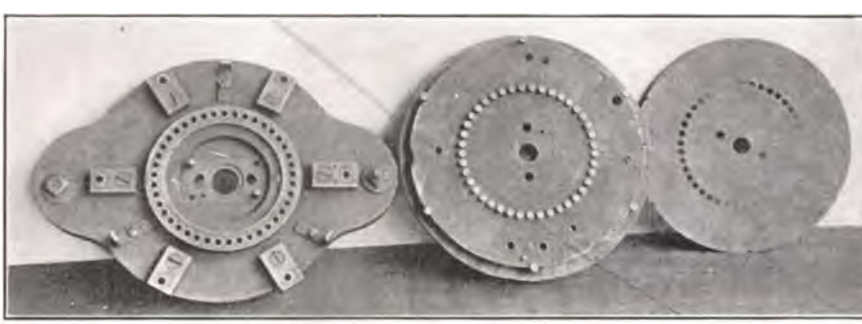


FIG. 92. — Multiple piercing dies for disks

a number of stiff spiral springs instead of by a rubber pad. The die is composed of small bushings hardened and ground and inserted in holes bored in a circle in the die base. These seats for the die bushes are readily located and bored by swinging the work on the dividing head of the milling machine, and the punch holder is similarly treated for the placing of the holes to receive the individual punches.

In addition to the 40 holes in the circle referred to there are six equi-

spaced holes punched at the same time in the edge of the disk. The position of the punches and die bushings for this purpose is seen clearly. Also the three stops for forming a locating nest for the round blanks will be noticed in the photograph.

Some interesting problems in tool work enter into the making of such dies, locating centers accurately and boring for various members. Each

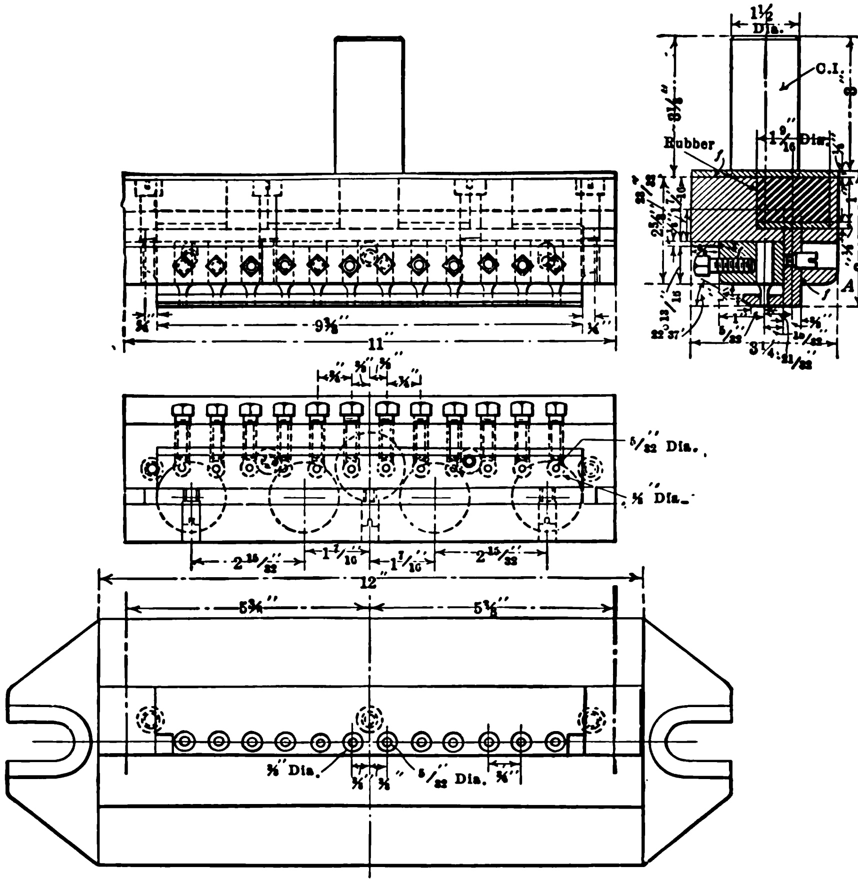


Fig. 93. — Multiple piercing dies

die illustrated in these chapters might be made the basis of a tool room story of importance if space were available for the purpose. However, the details of tool room operations for many typical cases will be covered in special chapters and an attempt will be made to deal sufficiently with principles and applications so that the handling of general punch and die work will be made clear to the reader not already versed in customary methods.

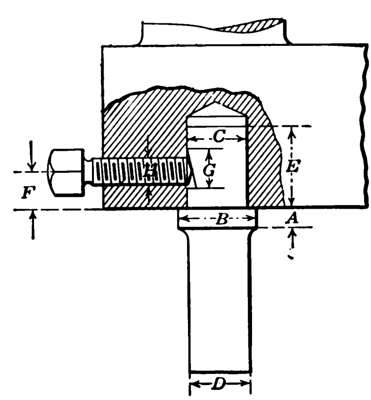
Another Bushed Die

The tools in Fig. 93 illustrate an example of a piercing die for making a long row of holes at one stroke, this design also embodying the principle of a bushed die block which, in this case, receives twelve die bushings set into the block as indicated.

The tools are for punching $\frac{5}{32}$-in. holes $\frac{3}{4}$ in. apart. The dies or bushings are $\frac{3}{8}$-in. deep. The punches are $\frac{3}{8}$-in. drill rod reduced at the end to the diameter specified. They are secured in their holder, a steel block, by set screws. The stripper has an angular form, with the back rising against a set of rubber plugs or springs carried as shown in the punch holder proper. A series of three short screws at A, traveling in vertical slots, limit the downward movement of the stripper. The dotted circles in the plan view of the punch bring out the method of positioning the rubber sections to give ample pressure to back up the stripper.

The punches in Table 8 are useful where they are close to the edge of the punch holder and therefore reached by set screws. The sizes given range from $\frac{1}{4}$ in. to 2 in. and they are suited for blanking as well as piercing operations.

Table 8. — Piercing Punches Held by Set Screws



D = diam.	A	B	C	E	F	G	H
Ins.							
$\frac{1}{4}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{3}{8}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{1}{2}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{1}{2}$	1	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{9}{16}$	$\frac{1}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{5}{8}$	$\frac{1}{8}$	$\frac{7}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{3}{4}$	$\frac{1}{8}$	$\frac{7}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{9}{16}$	$\frac{3}{8}$
$\frac{7}{8}$	$\frac{1}{8}$	1	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
1	$\frac{1}{8}$	1	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
$1\frac{1}{8}$	$\frac{1}{8}$	$1\frac{1}{8}$	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{7}{16}$
$1\frac{1}{4}$	$\frac{1}{8}$	$1\frac{1}{4}$	1	$1\frac{3}{4}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{1}{2}$
$1\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{2}$	1	$1\frac{3}{4}$	$\frac{7}{8}$	$\frac{11}{16}$	$\frac{1}{2}$
$1\frac{3}{4}$	$\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{7}{8}$	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{5}{8}$
2	$\frac{1}{8}$	2	$1\frac{3}{8}$	$1\frac{7}{8}$	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{5}{8}$

Second Operation Piercing Tools

There are numerous instances where work previously blanked goes to the piercing dies to have holes of one form or another punched through in a second operation. Several instances of the sort have been included in the examples of work handled in the dies illustrated in this chapter, these being in the main fairly large-sized pieces.

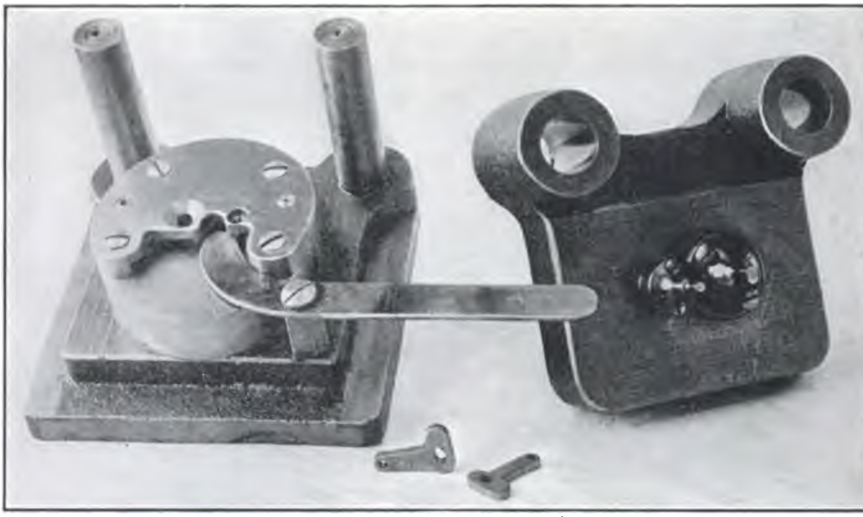


FIG. 94. — Piercing tools for blank with two holes

In Fig. 94 a pair of dies are shown for piercing two holes in the ends of the rocker shaped lever seen in the foreground. The round hole is less than $\frac{1}{8}$-in. diameter, the oblong hole in the body is $\frac{3}{16}$ by $\frac{5}{16}$ in. The piece is 0.140-in. thick and of steel.

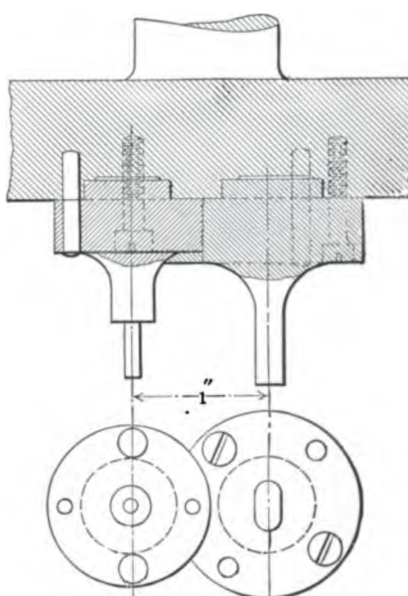


FIG. 95. — Double piercing punches

The method of holding is to slip the work under the stripper and hold it against the interior seat or open nest by means of the handle in front. The punches, as seen in Fig. 95, are machined upon large pieces of tool steel which form substantial bases and these are secured to the head by two fillister screws and two dowels each. The larger punch circle is cut out at the back to admit the edge of the other flange to allow the right center distance to be secured. The form of the punches is very rigid and there is little probability of their springing. This design of punch with solid back, which is turned down to give the punch size, is a commendable one, for it provides a rigid seat and a punch that cannot spring as would be the case were it straight all the way back and inserted simply in the holder forming the head of the subpressed dies.

The dies are round and of the proper size inserted in the base block. The stripper plate is countersunk around the holes to allow the short stiff punches to enter and clear at the point of enlargement.

Blanking and Piercing Dies

After all, the most commonly found cases of piercing operations are where they are in conjunction with blanking, the required holes being first pierced in the strip of stock and the next stroke of the press causing the

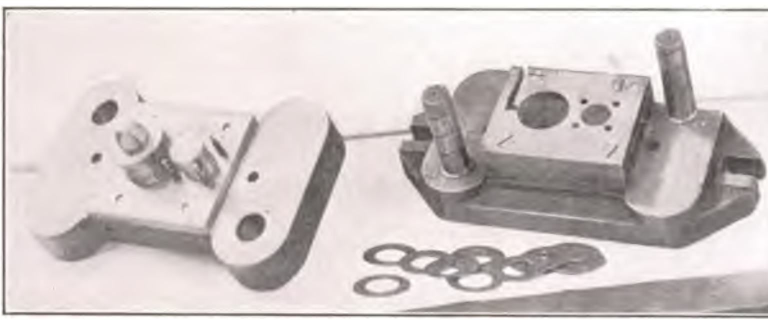


Fig. 96. — Progressive piercing and blanking dies for a special washer

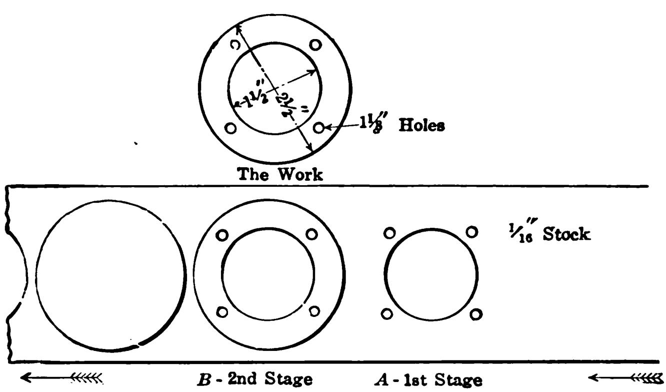


Fig. 97. — Successive steps in making the washer

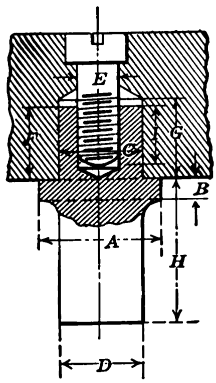
piece to be blanked out. A simple but good illustration of the principle is presented in Fig. 96 which shows a round washer with four small holes pierced at quarters around the circle.

The piercing tools are located at the right hand or the end where the stock enters. The center hole is here punched out and the four smaller holes pierced as at *A*, Fig. 97. The next advance of the stock allows the strip of metal to be located correctly by the pilot on the end of the blanking

punch so that as that punch passes through the stock the washer is blanked out concentrically as at *B*, Fig. 97.

A substantial type of punch for either piercing or blanking and one that

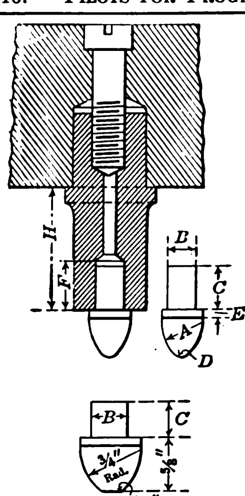
TABLE 9. — PUNCHES HELD BY SCREW TAPPED IN FROM THE TOP



D = diam. of punch	A	B	C	E	F	G	H	I
1/4	5/8	1/8	1/2	5/16	1	1 1/8	1 1/8	5/8
3/8	5/8	1/8	1/2	5/16	1	1 1/8	1 1/8	5/8
1/2	3/4	1/8	1/2	5/16	1	1 1/8	1 1/8	5/8
9/16	3/4	1/8	5/8	3/8	1	1 1/8	1 1/8	5/8
5/8	7/8	1/8	5/8	3/8	1	1 1/8	1 1/8	5/8
3/4	7/8	1/8	5/8	3/8	1	1 1/8	1 1/8	5/8
7/8	1	1/8	3/4	3/8	1	1 1/8	1 1/8	5/8
1	1 1/8	1/8	3/4	3/8	1	1 1/8	1 1/8	5/8
1 1/8	1 1/4	1/8	3/4	3/8	1	1 1/8	1 1/8	5/8
1 1/4	1 3/8	5/32	1	3/8	1	1 1/8	1 1/8	5/8
1 1/2	1 5/8	5/32	1	3/8	1	1 1/8	1 1/8	5/8
1 3/4	1 7/8	5/32	1 1/4	3/8	1	1 1/8	1 1/8	5/8
2	2 3/16	5/32	1 3/8	3/8	1	1 1/8	1 1/8	5/8

is secured in practically the same manner as the two larger ones in Fig. 96 is covered in various sizes by Table 9. This construction provides for the securing of the punch in its holder by means of a fillister head screw tapped in from the top as indicated. This method is the one used with many such punches as are illustrated in Fig. 96.

TABLE 10. — PILOTS FOR PROGRESSIVE BLANKING PUNCHES



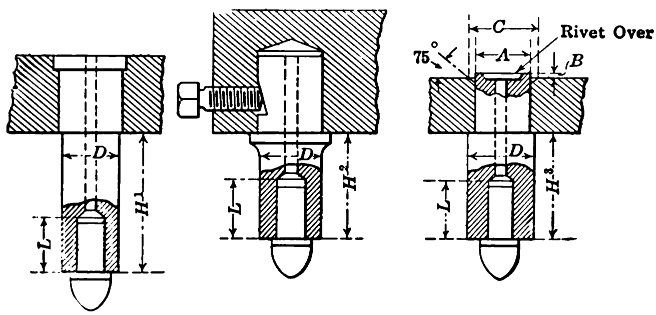
A	B	C	D	E	F	H
Ins.						
3/16	1/8	5/16	1/32	1/16	7/16	1 3/16
1/4	3/16	7/16	1/32	1/16	9/16	1 3/16
5/16	1/4	1/2	1/16	1/16	5/8	1 3/16
3/8	1/4	1/2	1/16	1/16	5/8	1 3/16
7/16	1/4	1/2	3/32	1/16	5/8	1 3/16
1/2	1/4	1/2	1/8	1/16	5/8	1 3/16
5/8	5/16	9/16	5/32	1/16	11/16	1 3/16
11/16	5/16	9/16	Flat end	1/16	11/16	1 3/16
3/4	3/8	5/8	Flat end	1/16	3/4	1 3/16
7/8	3/8	5/8	Flat end	1/16	3/4	1 3/16
1	7/16	11/16	Flat end	1/16	13/16	1 3/16
1 1/4	1/2	3/4	Flat end	1/16	7/8	1 3/16

Pilots

The pilot is inserted in the blanking punch and is made to a long radius, equal at least to the diameter of the pilot body. This question of pilots is of interest as they are so extensively used in connection with progressive dies. Table 10 herewith is laid out to cover pilot dimensions for the type of punch which is held by a fillister head screw tapped in from the top of the punch holder. The same dimensions apply also to pilots for the other

Table 11. — Progressive Blanking Punches with Pilots
For Pilot Dimensions Refer to Table 10

Make L for All Punches Equal to Pilot Shank + $\frac{1}{8}$ In. (See Table 10 for Pilots)



D = diam.	H^1	H^2	H^3	A	B	C
Ins.						
$\frac{1}{4}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{5}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{3}{8}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{7}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{1}{2}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{9}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	....	....	....	....
$\frac{5}{8}$	$1\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{5}{8}$
$\frac{11}{16}$	$1\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{5}{8}$
$\frac{3}{4}$	$1\frac{13}{16}$	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{16}$	$\frac{5}{8}$
$\frac{7}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{9}{16}$	$\frac{1}{16}$	$\frac{11}{16}$
1	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{5}{8}$	$\frac{1}{16}$	$\frac{3}{4}$
$1\frac{1}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{3}{4}$	$\frac{1}{16}$	$\frac{7}{8}$
$1\frac{1}{4}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$\frac{7}{8}$	$\frac{1}{16}$	1
$1\frac{1}{2}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{1}{8}$	$\frac{3}{32}$	$1\frac{5}{16}$
$1\frac{5}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{1}{4}$	$\frac{3}{32}$	$1\frac{7}{16}$
$1\frac{3}{4}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$\frac{3}{32}$	$1\frac{7}{16}$
$1\frac{7}{8}$	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{5}{16}$	$\frac{3}{32}$	$1\frac{1}{2}$
2	....	$1\frac{3}{16}$	$1\frac{3}{16}$	$1\frac{3}{8}$	$\frac{3}{32}$	$1\frac{9}{16}$
$2\frac{1}{8}$	....	....	$1\frac{3}{16}$	$1\frac{3}{8}$	$\frac{3}{32}$	$1\frac{9}{16}$
$2\frac{3}{8}$	....	....	$1\frac{3}{16}$	$1\frac{1}{2}$	$\frac{3}{32}$	$1\frac{11}{16}$
$2\frac{5}{8}$	....	....	$1\frac{3}{16}$	$1\frac{3}{4}$	$\frac{3}{32}$	$1\frac{15}{16}$
$2\frac{7}{8}$	....	....	$1\frac{3}{16}$	2	$\frac{3}{32}$	$2\frac{3}{16}$

classes of punches whose proportions are given in Tables 7, 8, and 11, and in all cases the pilots should be ground or otherwise finished on the stem or shank to a press fit in the ends of the blanking punches.

Ordinarily the pilots can be made of drill rod. In the smaller sizes, as indicated in the tables, the point of the pilot is rounded to a definite radius given in Column *D*, Table 10. For larger sizes of pilots the bottom end is flat, reducing the length accordingly, and the corners are rounded to a radius of $\frac{3}{16}$ in. These proportions are varied where necessary but for a wide range of work they have proved satisfactory.

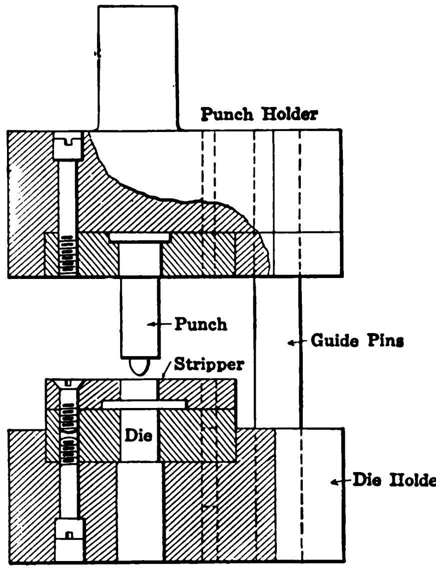


FIG. 98.—Construction for progressive dies

PROGRESSIVE DIE SECTION

The sectional view, Fig. 98, represents one standard form of construction for progressive dies with the tools shown on the vertical center line of the blanking punch. The die is here seen secured in its holder or base by fillister head screws and dowels which are independent of those used for attaching the stripper to the die.

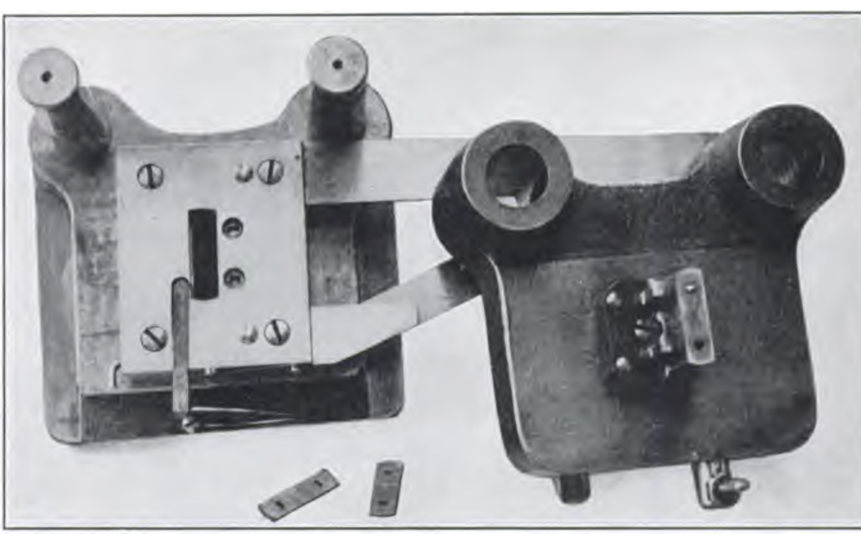


FIG. 99.—Progressive tools for piercing and blanking a rectangular part

The screws for the latter purpose are short countersunk head screws which may be removed to permit the stripper to be taken off and the die to be examined or ground without disturbing it in its holder.

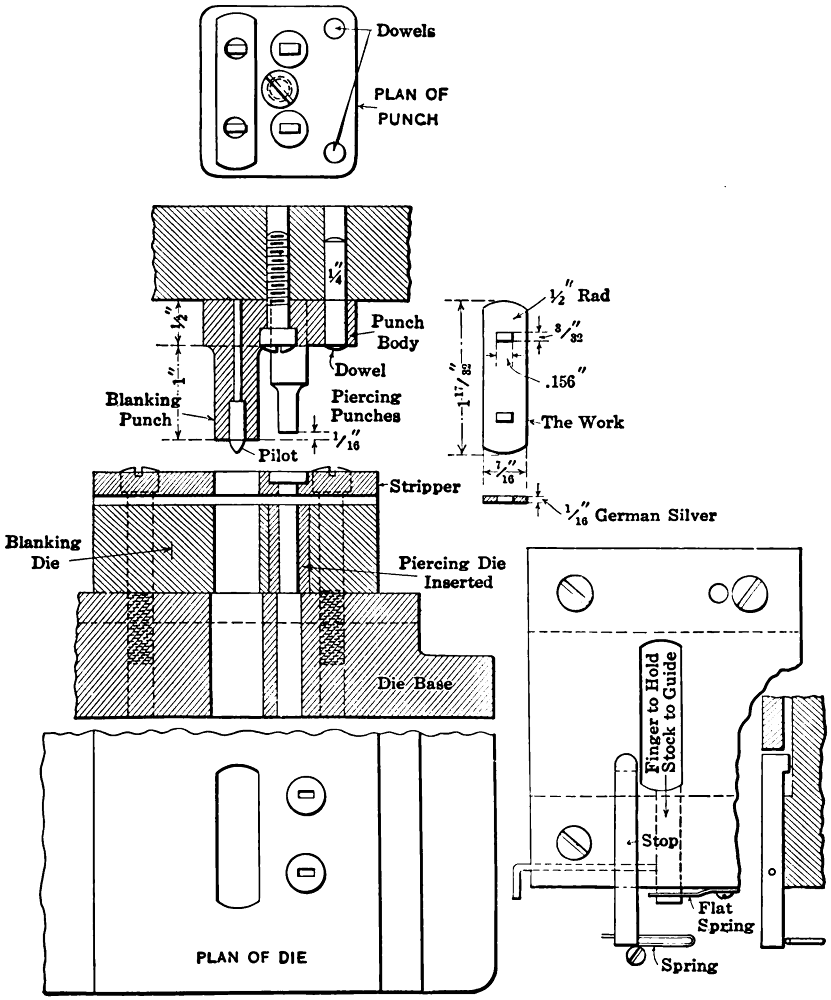


Fig. 100. — Details of tools in Fig. 99

This is an advantage over the alternative construction commonly used, where one set of screws and dowels are employed for both stripper and die.

Another Example

The piercing and blanking tools in Figs. 99 and 100 punch two small rectangular holes in the german silver stock and blank out the piece to the dimensions given in the latter drawing. These engravings show clearly

the method of making the main punch from a solid block and inserting in its body the two piercing punches, which are formed with round bodies for that purpose.

The punch rests squarely upon its base which has ample area to give it security and one fillister head screw and two dowels fasten it in place. The blanking portion of the punch is machined up mainly by milling and the large fillets in all corners give a rigidity that is most desirable in tools of this character. The two holes for the piercing punches are located accurately and bored through for the enlarged shanks and the piercing portions are left purposely short to provide further stiffness.

The piercing dies are of the button type inserted in seats in the main die in which they are pressed snugly. A stop of the trigger type is carried

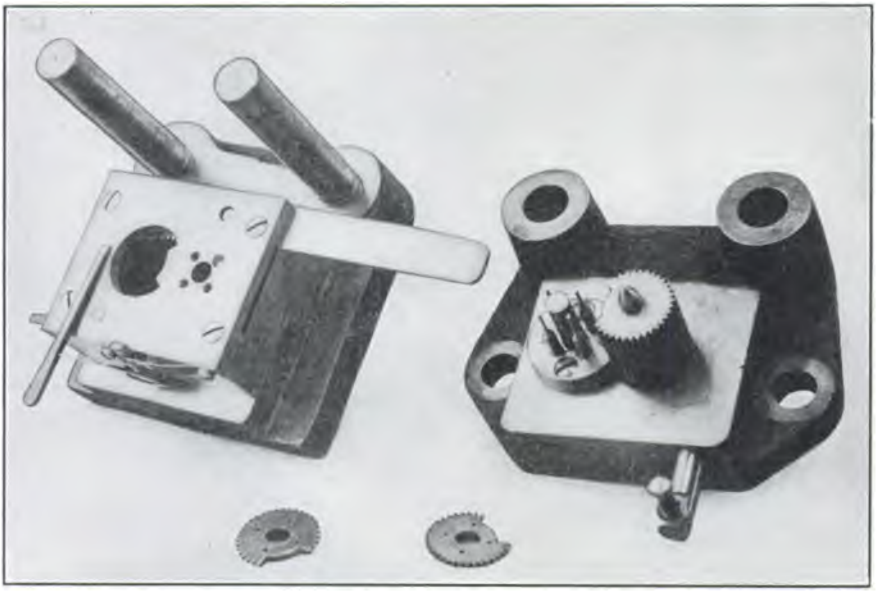


FIG. 101. — Progressive dies for an interrupted gear wheel

in the stripper as represented, and a finger, spring-actuated and adapted to press inward and hold the stock against the guide, is included at the side of the stop as seen in the sketch.

It will be noticed that the piercing punches are shorter than the blanking punch by a sufficient amount to allow the latter punch to strike through the stock before the piercing punches enter the work. This permits the blanking punch to locate the work properly by means of its pilots and also prevents any undue stress being imparted to the piercing punches by the action of the larger blanking punch upon striking the stock.

Tools for a Toothed Piece

A set of tools which combine in a different manner certain of the features of some of the dies already described are illustrated by Fig. 101. These produce the piece, Fig. 102, from $\frac{1}{16}$-in. steel stock.

The large piercing punch for the center of the gear disk is made with an enlarged base, as in previously shown constructions, and the four small piercing punches are inserted therein, the group of five punches then being secured by two screws and two dowels as plainly seen. The blanking punch is turned with a locating hub and secured by screw and dowels from the top of the punch holder. The punch teeth are milled by special cutters and similar cutters are used for making broaches for working out the teeth in the die which is finished out in the teeth by machine filing, broaching, hand filing, and lapping.

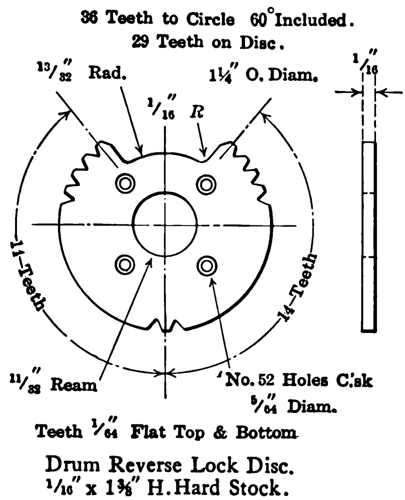


Fig. 102. — Detail of gear wheel

With the teeth worked out somewhere near to size, the broach is forced in $\frac{1}{64}$ in. or so, under a hand press, then hand filing is resorted to to remove the stock to the outline set in by the broach, after which the broach is again applied and forced down a little further, the process being repeated and filing being done to the point broached until the broach has been passed down through the die.

The details of operations on dies of this class with accurate tooth forms to produce, will be taken up at length in another section of this book. The dies just referred to are shown at this point to illustrate an interesting form of progressive tool that is put together in substantial fashion.

A Sheared Die

The die in Fig. 103 is for producing a flat blank from rather heavy stock, and to ease the action on the tools and work and produce a smoother, better job, the shearing principle has been adopted for the die face. The progressive feature for the piercing and blanking in sequence is apparent and the arrangement of piercing punch and the pilot in the blanking punch is likewise clear. The blanking punch is made with a wide base to seat in the crosswise channel in the holder and the screws are run in from the rear.

The shear on the die face is in the form of two concave surfaces covering about two-thirds the length of the die. The stripper has been removed in

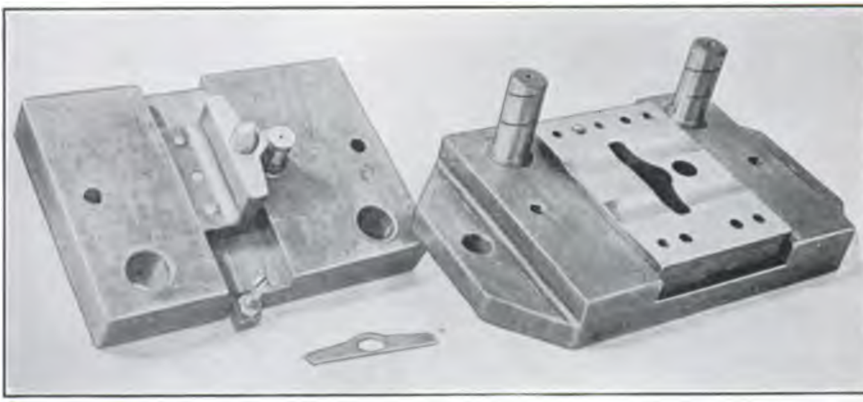


FIG. 103. — Progressive tools with sheared die face

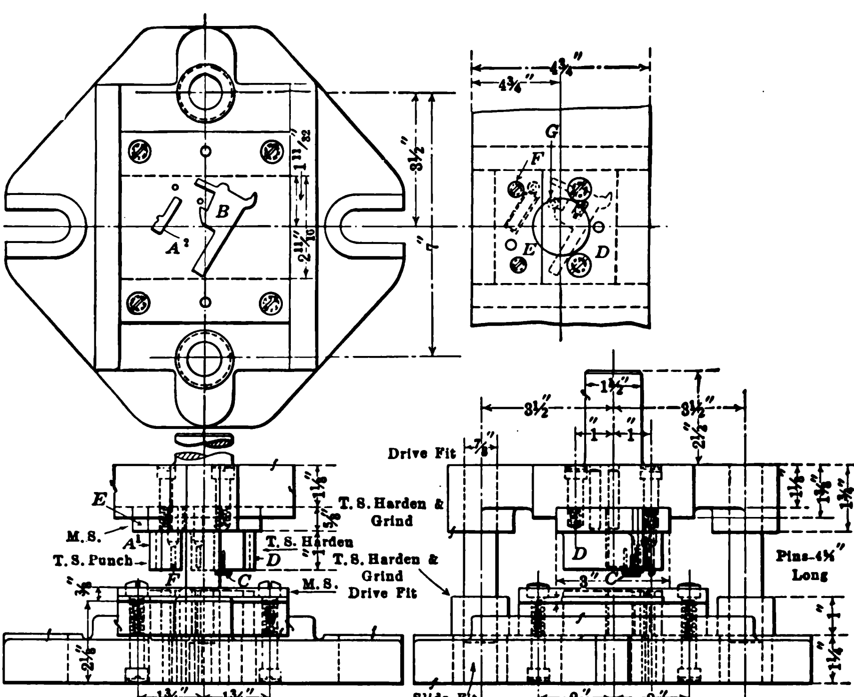


FIG. 104. — Piercing and blanking tools for a typewriter part

the view to permit the die to be shown more clearly. The concave shear is of course readily ground and the die is therefore easily kept in good condition for operation.

Piercing a Slot

Piercing dies are often required for forming irregular openings, long slots, and the like as well as for making round and square holes in the work. An example of a particularly neat set of tools of this character is represented by the piercing and blanking progressive die in Fig. 104. The piece blanked and pierced is shown by the detail, Fig. 105. This is a sheet steel typewriter part $\frac{3}{64}$-in. thick and is later bent in forming dies to finished shape. Only the blanking and piercing tools will be shown at this point however.

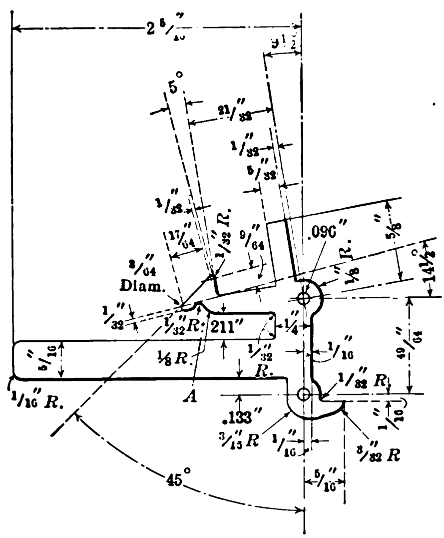


Fig. 105. — Detail of blank produced in the tools in Fig. 104

The well-proportioned punch and die parts are all shown in the assembly drawing, Fig. 104. The interesting feature of the tools in the present connection is the provision for piercing the opening at A, Fig. 105, with the punch A' and die A^2, Fig. 104, so that when the work advances to the blanking position, the cutting out of the blank is accomplished in die opening B, by the punch which shears across the lower end of the slot A, Fig. 105, and thus leaves that slot open at the end as required. This is a method frequently resorted to where one or more narrow slots are required with one end open as in the form of, say, a toothed comb; the oblong openings or slots can be pierced as completely enclosed holes and at the next stage or blanking process, the ends are opened by the blanking out of the piece.

There are also in the blank shown two small round holes that are pierced by the two inserted punches, 0.096 in. in diameter. The pilot for locating the work for the blanking is a rectangular piece shown at C which is fastened by a screw and two small dowels to the face of the blanking punch D.

The blanking punch is made in one piece of tool steel as indicated. The tool steel piercing punch A' for the slot is inserted in a separate steel plate E which is also bored to receive one of the small round punches F. The other small round punch G is inserted in a hole bored in the body of the blanking punch D. Each of the two punch bodies D and E is secured by

two fillister head screws and two dowels fitted in from the top of the punch holder. Both punches fit snugly in the seat planed out 3 in. wide by $\frac{1}{4}$-in. deep in the face of the punch holder. With the divided construction shown it is possible if required to grind and lap the joining edges of the punch bodies to bring the spacing between centers to closest degree of accuracy.

It will be apparent from the plan view of the die that the position of the work as pierced and blanked is such as to take a minimum of stock, the angle to which the piece is set allowing the hooked projection to be blanked from the tongue left by the preceding blank.

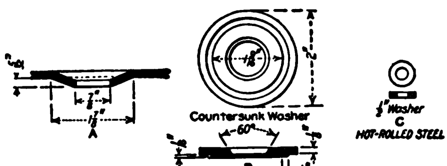


FIG. 106

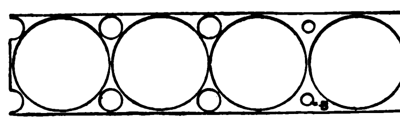


FIG. 109

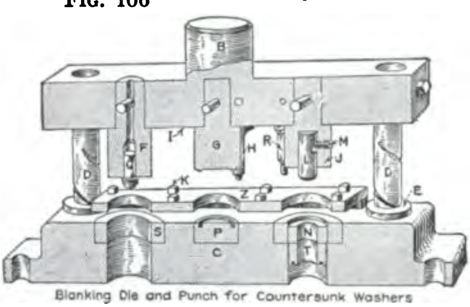


FIG. 107

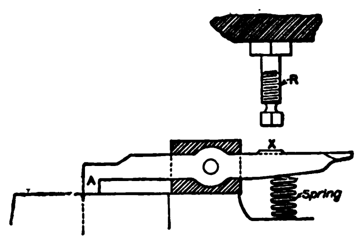


FIG. 108

FIGS. 106–109. — Blanking die and punch for countersunk washers

A THREE-STAGE SET OF DIES

Piercing operations in progressive dies are oftentimes combined with other work than merely blanking, three or four distinct sets of tools being then carried in the one pair of holders so that the job advances from one die to the next until completed, just as with the piercing and blanking tools already illustrated.

An illustration of a piece of work requiring piercing, forming, and blanking as produced in a progressive die is shown by Fig. 106. This is a counter-sunk washer made from $\frac{1}{8}$-in. rolled stock.

The dies are seen in Fig. 107, and the trigger gage or stop for automatically locating the stock is shown by the detail in Fig. 108. The counter-sinking to 60 degrees was originally performed in the drill press but this was found a comparatively slow process and so the press tools were designed as shown to take care of the counter-sinking also, this present

arrangement producing 3500 large counter-sunk washers and 7000 $\frac{1}{2}$-in. plain washers per hour. The latter are blanked out from the space left between the large washer blanks, as indicated in Fig. 109 which shows the scrap and gives an idea of the small amount of steel wasted in the work.

The large washer shown pierced and drawn down at A, Fig. 106, has been passed through the first operation in the die N and punch L, Fig. 107.

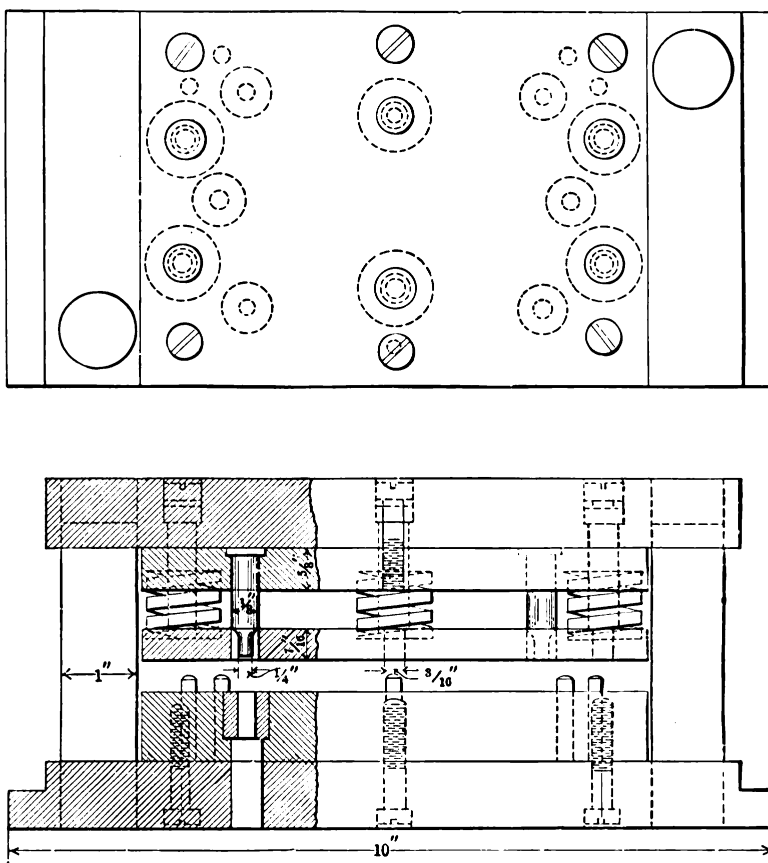


FIG. 110. — Multiple piercing tools for a sheared plate

The surplus stock is here drawn to the bottom by the punch L which, continuing downward, pierces a $\frac{7}{8}$-in. hole through the stock. Upon the upstroke of the punch the strip of steel is advanced to allow the blanking punch H to remove the $\frac{1}{2}$-in. washer. At the same time the first operation is repeated.

As the stock again advances it comes to the punch G and die P. The dished stock shown at A, Fig. 106, is now flattened, forming the desired counter-sink, and at the same time it is embossed by the punch G and the

die *P*. As the stock is advanced for the third operation the counter-sunk washer is blanked out by the die *S* and the punch *F* which is provided with a pilot *Q*, inserted in the manner shown.

The punch holder *B* is made of cast steel and the die plate *C* of cast iron. They are properly alined by the guide pins *D* and the bushings *E*

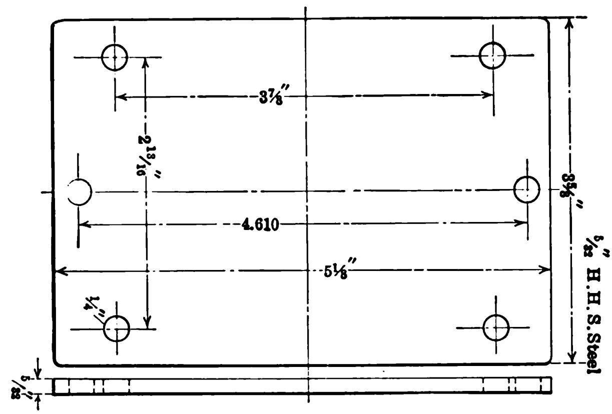


Fig. 111. — The plate as pierced with the tools in Fig. 110

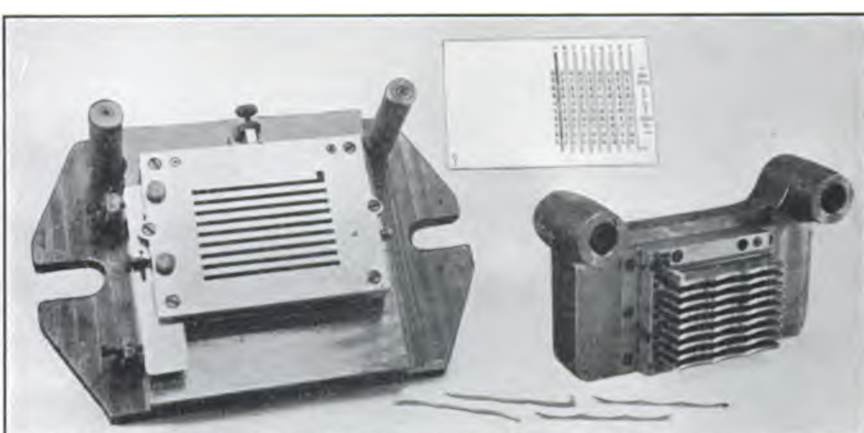


Fig. 112. — A sectional die for piercing a series of slots

which are pressed into position and lapped to fit the guide pins. Under operating conditions the guide pins are well lubricated. The punches *F*, *G*, *H*, *R*, and *J* are held in position by taper pins. The dies are pressed into position in their seats in the die plate *C*.

The stripper *Z* is held in place by cap screws *K*. The perforating punch *L* is secured by the headless screw *M*. The die *N* is adjustable

vertically in its seat by means of the threaded sleeve T. Small pinholes in the bottom and a pin spanner are provided for purposes of adjustment.

Referring again to the trigger stop or gage, Fig. 108, this works auto-

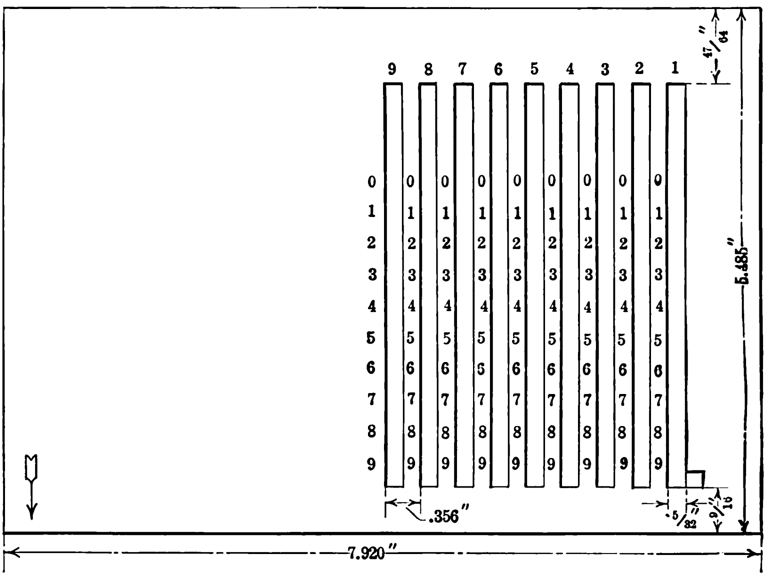


FIG. 113. — The work with slots pierced

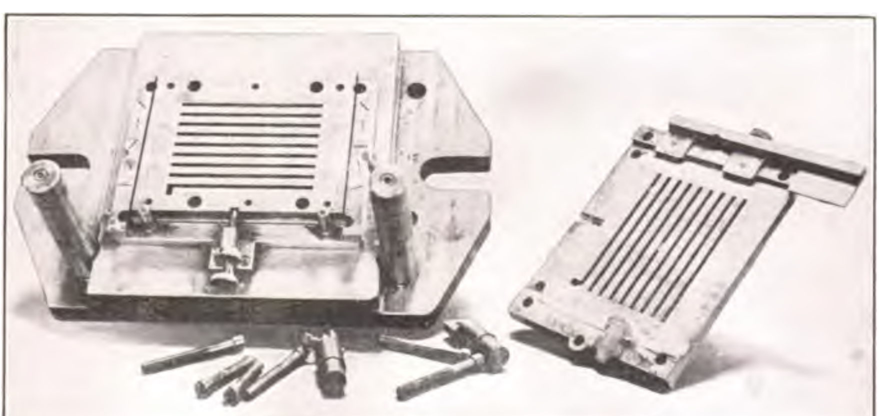
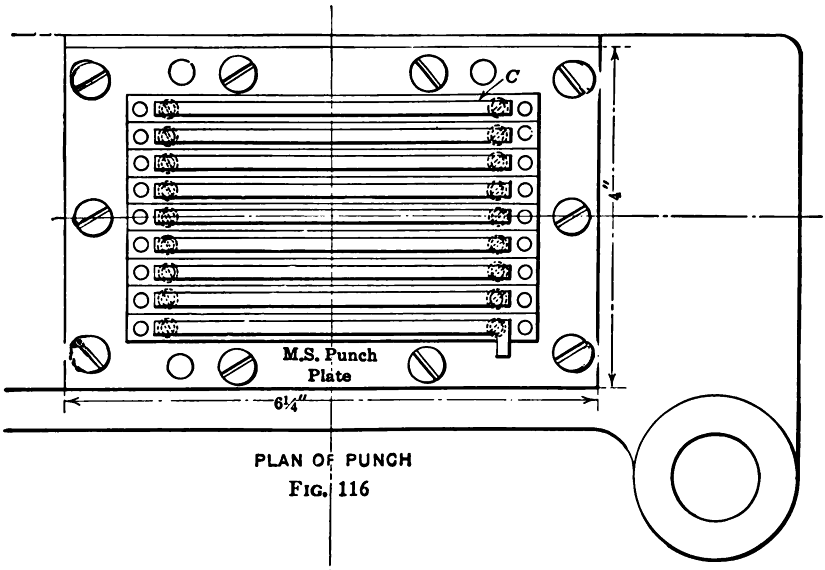


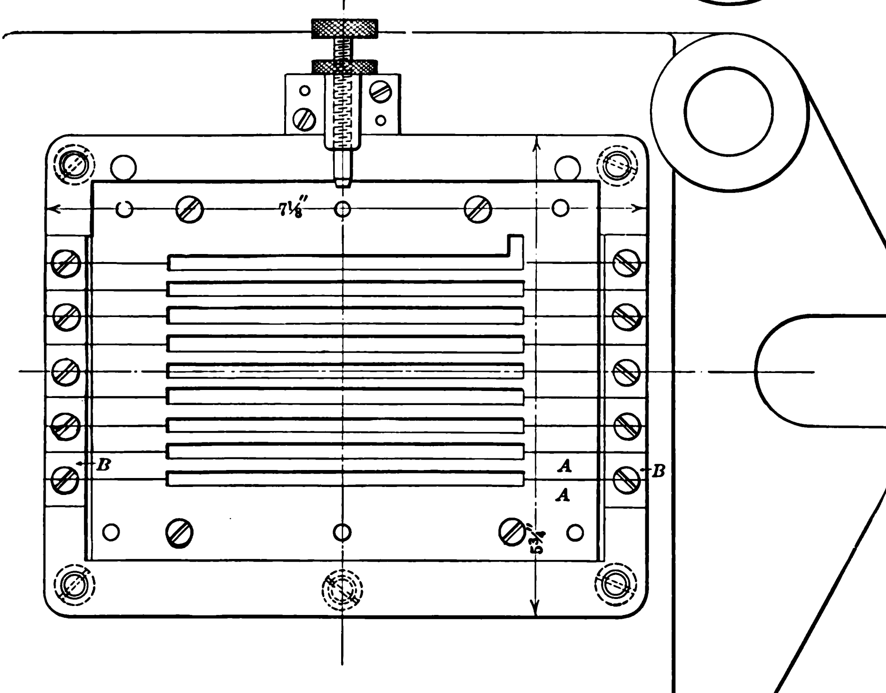
FIG. 114. — Sectional slot die details

matically under operating conditions by the proper adjustment of the set screw and lock nut R which is here seen in the side elevation of the automatic spacing gage. As the punch descends, the screw strikes at X and causes the inner end of the gage A to be raised out of the hole B, Fig. 109, in the edge of the stock.



PLAN OF PUNCH

FIG. 116



PLAN OF DIE

FIG. 115

FIGS. 115–116. — Plan of slot piercing punch and die

Dies with Spring Plate or Stripper for the Punches

The tools in Fig. 110 for piercing the six holes in the plate, Fig. 111, resemble somewhat in appearance a compound die in that they carry a spring actuated pressure pad and stripper for the punches. The latter are $\frac{1}{4}$-in. diameter and the plate operated upon is a steel member $\frac{5}{32}$-in. thick for a coin register. The dies are for piercing only as the piece is blanked in a previous operation.

The six dies are inserted in the steel plate as indicated and the die holder fastened by screws and dowels to the base plate. The punches are

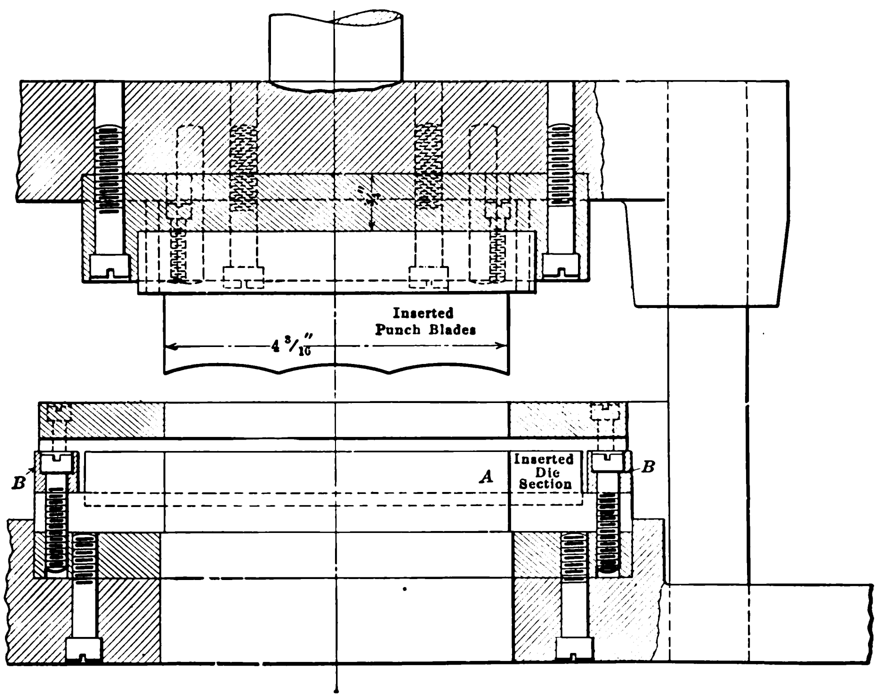


Fig. 117. — Longitudinal section through punch and die

made with $\frac{3}{8}$-in. bodies and with enlarged head so that they are seated in the steel punch plate which is itself attached to the main head by fillister head screws and dowel pins. There are six heavy springs for controlling the stripper plate.

The locating stops for the work are a series of $\frac{3}{16}$-in. pins inserted in the die as shown.

This type of die is used extensively for various classes of work where holes are required to be pierced in parts already blanked. The general arrangement of the punches and stripper are quite similar to that found in the construction of the smaller set of tools in Figs. 89 and 90 for perforating

the bottom of the article there shown. The dies in Fig. 110, however, are of the pillar type which insures alinement of the tools at all times. The arrangement of the springs for the stripper is along the lines followed very often with compound dies where work is blanked and pierced at a single stroke in distinction from the follow dies shown in this chapter where the piercing is done first and the stock then advanced to a second position for the blanking out of the piece.

Details of construction of compound dies are taken up in the chapter which follows. There are a few more types of piercing dies to be shown

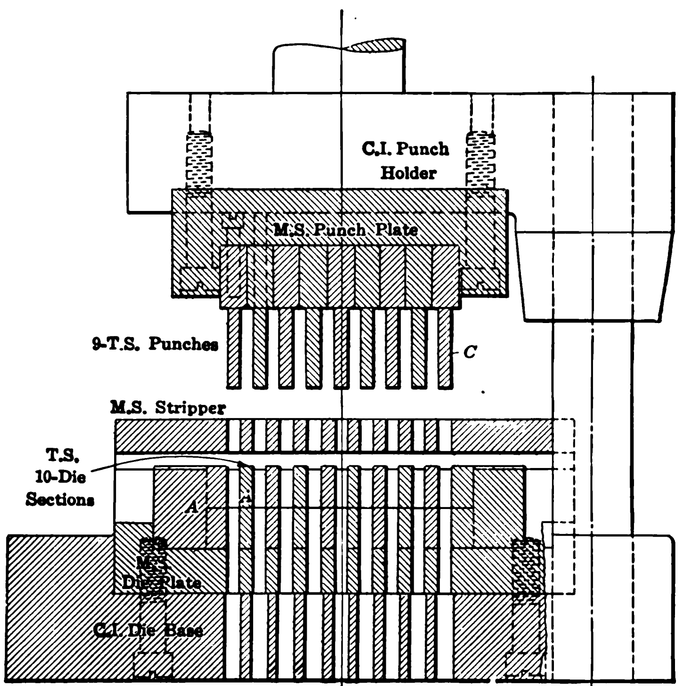


FIG. 118. — Cross section through punch and die

in the present chapter and one of these which embodies some very interesting features is represented by Fig. 112.

A Sectional Slot-piercing Die

The press tools in this view accomplish the piercing of the series of nine slots in the steel cover plate shown in the background of the photograph. The piece is afterward formed up for a dial cover for a calculating machine. It is cut out first to a blank 7.920 by 5.485 in. as in Fig. 113 and is then stamped in dies which mark the numerals seen between the slots and at their ends. The slots are then formed with the piercing dies, Fig. 112.

which operation naturally follows the stamping in of the characters in the face of the blank in order to avoid the distortion that would be caused by the stamping of the numbers if done after the slots were made.

The slots are practically $\frac{5}{32}$-in. wide and the width occupied by one slot and the adjoining stamped section is 0.356 in. The punch and die are shown with stripper removed in the view in Fig. 114 and a plan view of the inserted sections for both members is given in Figs. 115 and 116. The view, Fig. 114, shows the stop gage and guide for the blank at rear and side. The drawings, Figs. 117 and 118, show respectively longitudinal and cross sections and a detail of one of the punch and die sections is reproduced in Fig. 119. The different drawings referred to give a clear idea of all construction features.

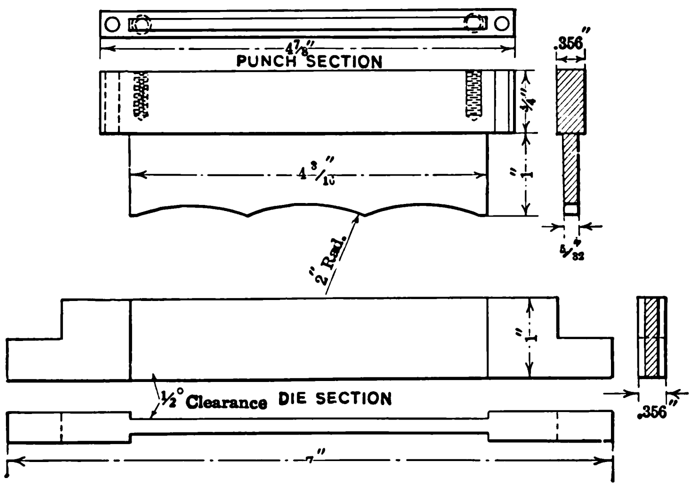


FIG. 119. — Detail of punch and die parts

THE DIE PARTS

From Figs. 115, 117, and 118 it will be seen that the tool steel die sections are let into a steel plate or holder which, in turn, is secured in a seat in the base casting by means of fillister head screws. Here the die sections or blades *A* are fitted snugly together and clamped at the ends by the steel strips shown at *B*. The die sections are made with their ends of the right width to give the exact spacing required between slots and the narrow central portions are finished precisely central with the widened ends. They are finished $\frac{1}{2}$ degree taper on the sides to give the clearance desired between them, or the same as if they were all worked out from a solid piece of tool steel.

The sections were milled out from stock of suitable width, a few thousandths being left for grinding and lapping to exact dimensions, then they

were hardened and drawn, and then placed on the magnetic chuck for surface grinding. This was followed by lapping dead to size.

It may appear that the sections could have been made simpler for facilitating the finishing processes but there are certain decided advantages with the form shown where the long body is central with the wide ends. For instance, the simplest method to occur to one might be the construction at *X*, Fig. 120, where the die blades *a* are straight from end to end and are spaced by blocks *b* equal to the width of slot required in the work. This arrangement, however, multiplies the number of parts, and increases correspondingly the number of surfaces to be finished accurately; moreover, once completed, there is some question if there might not be a tendency for the long blades to spring away slightly from the bearing joint between the spacing sections, thus giving a less rigid construction than the one actually employed.

Another possible design is represented at *Y*, Fig. 121. Here the recess for the die opening is all at one side of the section, the ends being of the

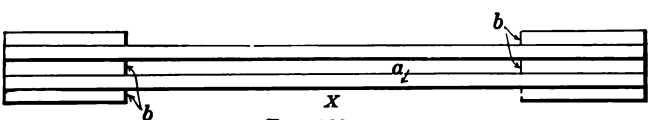


Fig. 120

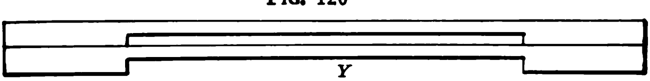


Fig. 121

Figs. 120–121. — Other possible forms of die sections

same width as when the symmetrical form of Fig. 115 is used. While there is some advantage here in doing all the cutting in of the metal from one side with a plain flat surface opposite, there is still a difficulty in connection with the hardening that is likely to offset this in a measure. As with any member that is offset, eccentric or so shaped that the cross-sectional area is unevenly distributed in relation to the axis of the piece as a whole, there is likely to be distortion when the work is hardened and this necessitates provision for the removing of more material by grinding after the work has been through the fire. Experience on other work with the two forms of die sections at *X* and *Y* led the designers of the sectional die described to use the form of inserted member illustrated in Fig. 115.

The Punches

The form of the punch sections is shown by the drawings to be symmetrical also, the blades being placed centrally with their backs and permitting of ready machining and of accurate finishing by grinding and lapping.

These punch sections are secured as at *C*, Figs. 115 and 118, in a steel

holder or plate which is machined out to let the sections enter as a snug fit when finished to correct length and thickness. The punch sections are also secured by small fillister head screws and dowels as represented in the plan view.

The flat steel holder or punch plate is $\frac{3}{4}$-in. thick through the bottom and is itself fastened to and located on the cast head by screws and dowel pins. The two members, base and head, of this set of tools are alined and kept in condition by the large guide posts or pillars at the back.

The punches, it will be noticed, are adapted for a shearing cut on the metal, by having three concave portions along their cutting edges which are

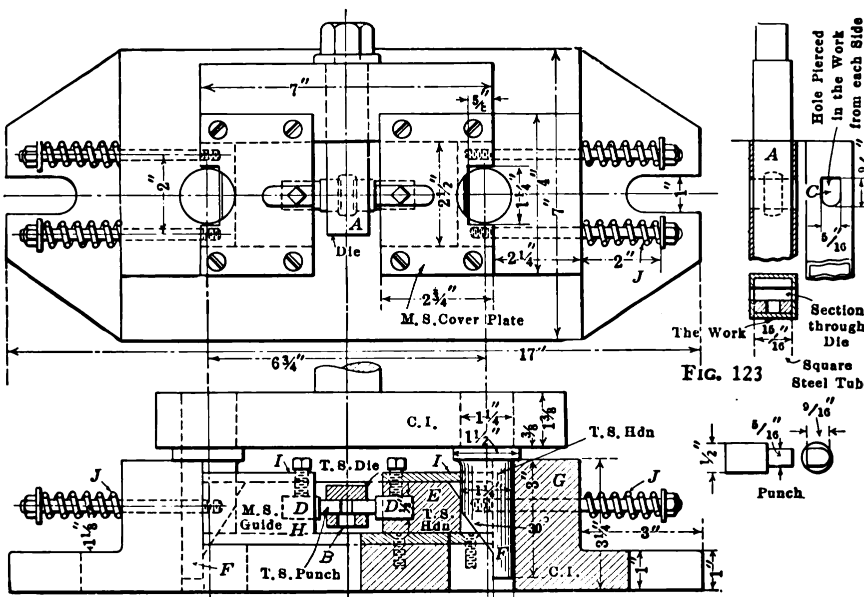


Fig. 123

Fig. 122

Figs. 122–123. — Side piercing tools

ground in with the circumference of the wheel so that they are kept sharpened as readily as if they were of the conventional flat form. This method of shearing allows the work to be slotted with the narrow closely spaced punches without danger of "dragging" the metal and producing rough irregular edges along the slots.

Side Piercing Tools

There are instances where work, cylindrical or other, requires piercing from the side and the punches in such cases are operated radially or toward the center of the piece by tapered or bevel-faced plungers carried by the upper member of the die set and acting against pressure springs which

return the punch slide to normal position upon the up-stroke of the press. A typical case is illustrated by Fig. 122.

In some cases a large number of holes are pierced simultaneously through the work by the necessary number of punches all carried by sliding members operated in similar fashion to the ones described. And these side piercing punches may be designed to be operated either toward the center by some form of closing-in device, or on the other hand expanded and forced outwardly by a tapered plunger or its equivalent at the center. The direction of the working stroke of the punch depends upon the size and character of the piece to be pierced.

Referring now to Fig. 122, this shows a set of piercing tools for punching two holes in opposite sides of the square tube seen at the right in the drawing, Fig. 123. The tube is of steel, $1\frac{5}{8}$-in. square inside and the method of supporting in the dies is to slip the piece of work over the member *A* which may be called a horn die in this instance, as it projects in the form of a bar from the shank which is fitted in the wall at the back of the die base. The support *A* is finished out through the sides to form the die openings and a slot is cut in the bottom at *B* to allow the slugs to drop through. The shape of the die is seen at *C* where the hole is shown $\frac{5}{16}$-in. wide by $\frac{9}{16}$-in. long with the front end formed to a half circle.

The Punches and Holders

The two side-piercing punches are set into holders as at *D*, the blocks *E* being adapted to travel longitudinally to force the punches through the work when the plungers *F* descend with the down stroke of the press slide. These plungers are secured in a regular punch holder or head and are of tool steel, hardened. They are machined to an angle of 30 degrees for a portion of their length and a corresponding slope is formed upon the rear ends of the punch slides *E*, *E*. The plungers *F* are cylindrical except for the sloping portion referred to, and they fit so as to slide closely in holes bored in the die shoe which at the ends is cast with a rectangular boss or projection *G* to provide sufficient height for a satisfactory guide for the plungers or pins *F*.

The casting is originally made with portion *G* wide enough to allow the full diameter of the hole to be bored down through and is afterward planed away at the front, as indicated, to form clearance and allow the plunger to act against the beveled end of the punch slide *E*.

The two punch slides *E*, *E*, are of tool steel, hardened, and they slide in machine steel guides *H* which are secured by counter-sunk head screws and dowel pins to the die shoe. The slides are $2\frac{1}{2}$ in. wide and when fitted to their horizontal guides they are prevented from lifting by cover plates 1 which are held by fillister head screws to the guide block. The cover

plates are slotted at their inner ends to clear the tops of the set screws for holding the piercing punches.

The slides with their punches are withdrawn upon the upstroke of the press by means of the compression springs *JJ* which are located upon studs tapped into the rear of the slides and fitted freely in holes drilled horizontally through the casting at *G*. The springs act against the washer and nut at the outer end of the studs and thus force the studs and punch slides outward when the bevel plungers are returned to their upper position.

Tools for Piercing Oblique Holes

Following along to other special forms of piercing tools we come naturally to the problem of piercing holes at an angle, and one set of tools for this purpose which should be helpful in the way of a suggestion for handling various jobs of similar character will be seen in Fig. 124.

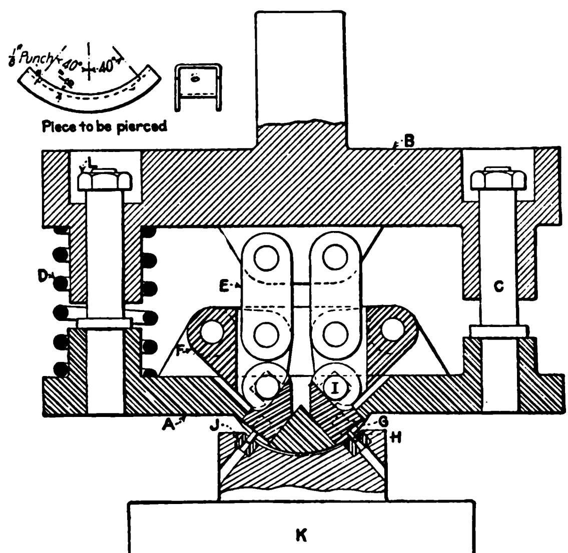


Fig. 124. — Dies for piercing oblique holes

This die was designed to pierce two $\frac{1}{8}$-in. holes at an angle of 40 degrees through the arc-shaped piece in the upper corner of the engraving. The cast steel blank holder *A* in these tools is suspended from the cast iron secondary ram *B*, or upper member of the dies, by the guide pins *C* which are pressed into *A* and made a sliding fit in *B*. The springs *D* transmit power for the blank holder *A*. The links *E* are hinged on the member *B* and on the punch operating members *F*, which in turn are pivoted in the lugs cast integrally with the blank holder.

The punch holders *G* which are a sliding fit in *A* carry the two piercing

punches *H*. The hardened steel pin *I* is pressed into the punch holder *G* and serves as a rest for the forcing device *F* which is cut out square to allow for the angular movement of the punch holders. The button dies *J* are pressed into the cast iron base *K*.

The drawing shows the die at the bottom of the stroke. The die operates as follows: The blank holder *A* and the secondary ram *B* descend as a unit until the blank holder strikes the piece to be pierced, holding it securely on the die. The secondary ram *B* continues its downward course, setting the toggle arrangement in motion, thus piercing the holes. On the return stroke the ram *B* ascends, withdrawing the piercing punches and stripping the work. The blank holder remains stationary until the nuts *L* bottom in the counter-bored holes. The ram and holder then ascend together.

CHAPTER IV

COMPOUND DIES FOR BLANKING AND PIERCING

Compound dies combine in one set of tools located about the same *vertical axis* or center line, the functions of two distinct classes of dies, say piercing and blanking, so that at each stroke of the press a blank is cut and one or more holes pierced through it without its being moved except as it is ejected from the dies upon the upstroke of the machine. This arrangement is therefore entirely different from the progressive or follow type of die where piercing of the stock occurs with the work in the first position in the tools and the stock is then advanced to the second position for the blanking out of the piece.

The compound construction means that the piercing punch must be located inside of the blanking die and the piercing die formed inside of the blanking punch. There are occasions where work is blanked and drawn in what may be designated as compound tools, particularly where a further operation of piercing is also accomplished at the same time, but as a rule the class of press tools used for blanking and drawing or for blanking, drawing, and beading, etc., in a single stage operation in a single action press are generally known as *combination* dies which are fully described in another chapter.

Compound Dies for a Brass Disk

A good example of a compound die and punch is represented by the tools in Figs. 125, 126, and 127. These were made for producing a brass disk $1\frac{1}{8}$-in. diameter with two holes pierced 0.10-in. diameter by $\frac{3}{4}$-in. apart. The stock used is $\frac{1}{32}$-in. thick.

The blanking punch for the disk is shown at *A*, Fig. 127, the blanking die at *B*, the piercing punches at *C*, the piercing die holes at *D*. The blanking punch is drilled out at the two points *D* as indicated to form the piercing die openings; the blanking die *B* carries a knock out or ejector which is drilled and counterbored from the rear to receive the two piercing punches *C*.

The blanking die measures $1\frac{1}{4}$-in. diameter across the body, which is shouldered as represented to correspond to the internal shoulder of clamping ring *E*. This ring serves to house in all members of the lower die and acts as a locating medium in the die base, in that it is fitted into a shallow

seat bored into the face of the base and is there located and secured by two dowel pins and four fillister head screws. These screws are tapped in from the under side of the die ring, as will be seen from the photographic view of the back of the die in Fig. 126.

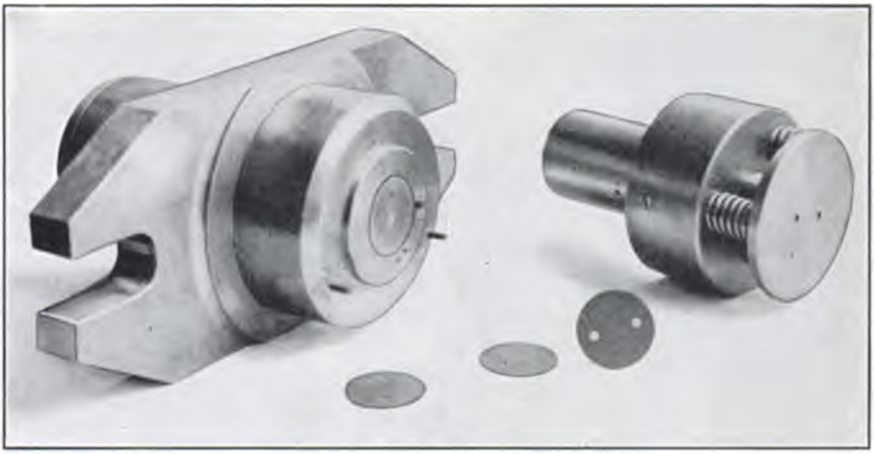


FIG. 125. — Compound die for blanking and piercing a small disk

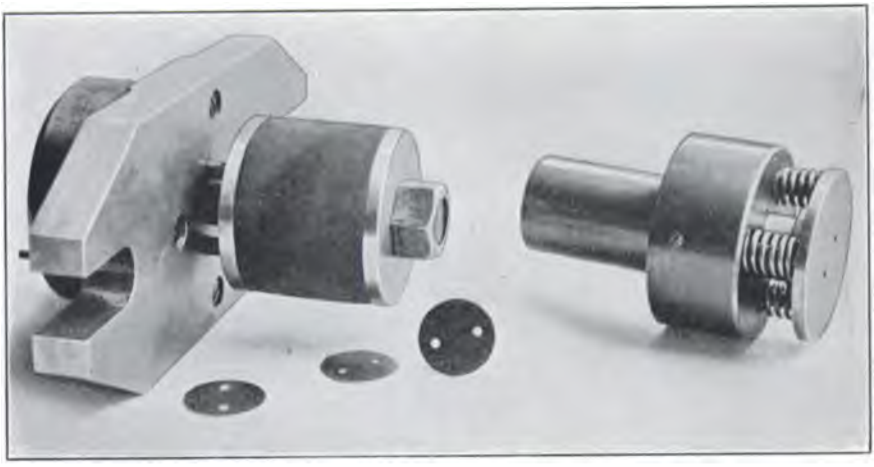


FIG. 126. — Rubber buffer or spring on compound die

Blanking die B rests upon the chambered ring F which fits the bore of the retaining ring or housing E and which is recessed out to a diameter sufficient to receive the flanged base of the ejector or knock out G. This is a nice sliding fit in the die and it serves as a guide for the slender piercing

punches *C*. The latter are made with enlarged bodies and heads and are secured by being let in from the under side of the ring *F* which is counterbored to conform to the dimensions of the heads of the punches.

Operation of Knock Out

The knock out is normally held in uppermost position as indicated by the pins *H* and the rubber spring *I*, the latter being retained between two steel plates and the whole unit of rubber, washers, and carrying stud being easily removable at any time. It is the practice in many places to make one or two of these rubber shedder outfits do duty with a number of different sets of dies as required. The device is attached to any set going into the press and is removed and transferred to another pair of dies when the first job is completed. This simplifies the making of the tools in the first place and where any given set of dies is used only occasionally a considerable measure of economy is effected.

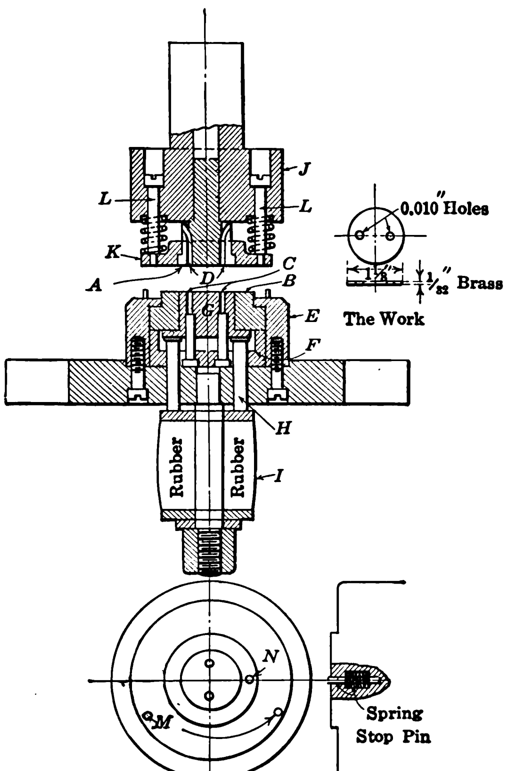


Fig. 127. — Details of compound die

While the dies in the views referred to here are shown with the rubber form of spring, such tools are very commonly made with steel compression springs of various sections which are used for operating the shedders and knock outs. Some die makers prefer the steel spring and others the rubber. Each has advantages and very often the question of limitation of space in the tools or press determines the spring medium that shall be employed.

Where space is available it is desirable to make the ejector pins *H* with small heads in order that they may not fall out when the rubber or spring device at the bottom is removed.

Blanking Punch Details

The blanking punch *A* is secured in the holder *J* and is enclosed in the shedder ring or stripper ring *K* which is normally forced down to the lower position shown by the action of the pressure springs on the fillister head screws *L*. The two openings constituting the piercing dies are drilled in the blanking punch and at their upper ends two holes are drilled in at an angle to form a passage out of the punch for the slugs as pierced out of the blank by punches *C* below.

Two guide pins for the strip of stock are located at *M* and a stop gage at *N*, as seen in the detail sketch below the die. The stop *N* is spring actuated and when the punch descends the combined pressure pad for the stock and stripper *K* forces the pin downward. The blanking punch continuing to descend blanks out the disk in die *B* and the two piercing punches *C* pierce the small holes, the blanking punch forcing the shedder *G* downward against the action of the rubber below. Upon the upstroke the shedder *G* rises, clearing the blanked and pierced disk from the blanking

Fig. 128. — Compound piercing and blanking dies

Fig. 129. — Progressive piercing and blanking dies

die and piercing punches, and at the same time the stripper *K* strips the stock from the blanking punch *A*.

It should be noted that the small die holes *D* in the blanking punch are originally drilled and reamed all the way through the blanking punch to enable the holes to be taper reamed from the top to an angle of 2½ degrees for clearance for the slugs. Afterward the tops of the small die holes are plugged as indicated and the passage of the slugs deflected by the side openings at an angle in the die. The punches *A* and *C* and die *B* are of tool steel hardened.

A Contrast in Construction

The two sets of dies in Figs. 128 and 129 are shown together to illustrate the differences in construction in the open progressive die in the latter view and the compound die in Fig. 128. These two sets of tools are for

practically the same kind and size of work and form good subjects for comparison.

The work pierced and blanked is, in each instance, about 4 in. long by 1 in. wide. The hole pierced is $\frac{5}{8}$-in. diameter. The features of the progressive dies at the right in Fig. 129 are clearly seen and require little

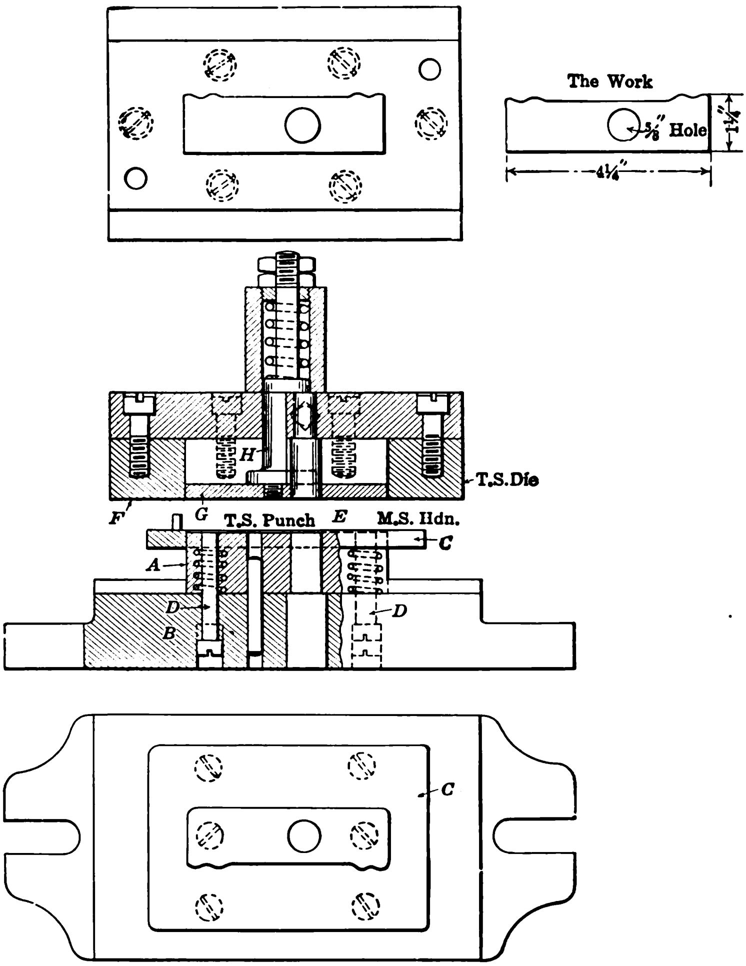


FIG. 130. — Construction of compound die

explanation. This die happens to have a long stock support and guide attached at the right-hand side and the strip of metal feeding along this member is first pierced with the punch and die opening at the side of the die and then advances to the next position where it is blanked at the same stroke that pierces the hole in the stock for the next blank, and so on.

The compound die in Fig. 128 is made up as shown by the drawing, Fig.

130. The blanking punch A is here inverted and carried by the lower shoe B to which it is secured by fillister head screws and dowels. It is provided with a spring actuated stripper plate C which is forced upward by the compression springs on the four screws D. This stripper plate carries the gage pins for locating the stock.

The piercing die is formed in the blanking punch and the piercing punch E and blanking die F are carried by the upper head, the parts being secured as shown. The blanking die is provided with the knock out G which is carried by the spring plunger H. The work blanked is quite thin and the spring knock out is therefore sufficiently stiff to answer the purpose for which it is intended.

It will be seen that the work pierced and blanked in a compound die of this type is handled under several advantages as compared with the pro-

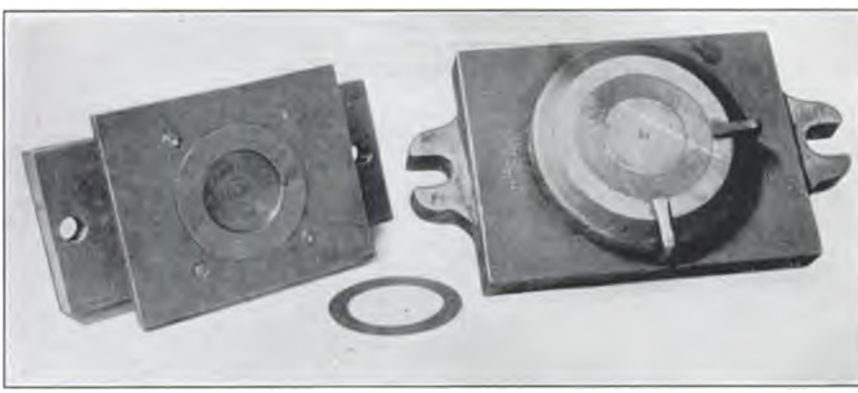


FIG. 131. — Dies for thin ring or washer

gressive type of tools. In the first place the blanking and piercing being accomplished simultaneously, accuracy of the hole position is assured in respect to the edges of the blank. As the stock is held between the pressure pad and the face of the die, and the blank as produced is supported by the knock out in the die, the work is necessarily kept flat and free from wrinkles and distortion. The piece of work produced in the dies shown is, of course, of a simple character, but as we proceed with other examples of compound die work we shall find some more intricate constructions.

MAKING A THIN STEEL RING

In Fig. 131 a set of tools are shown for making a steel washer of light-gage stock. The outside diameter of the work is 3 in., the hole blanked out at the center is 2 in. The dies are of the compound order and the details of the different parts will be seen in Figs. 132 and 133.

The tool steel blanking die A is secured in the cast shoe B and the tool

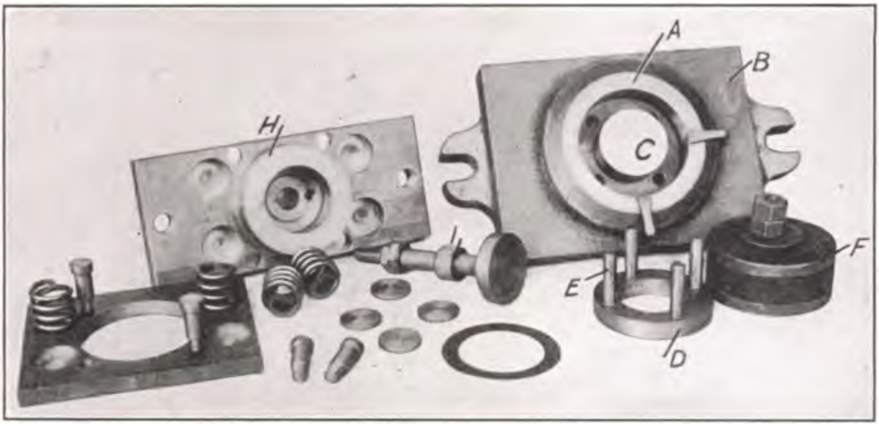


Fig. 132. — Showing details of tools in Fig. 131

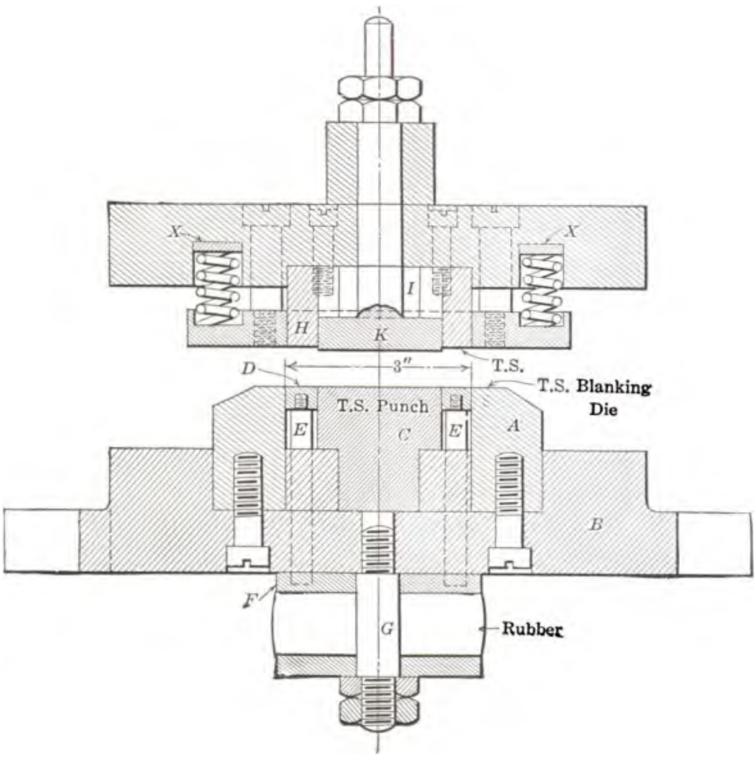


Fig. 133. — Sectional view of the dies in Fig. 131

steel piercing punch *C* is located concentric with the die and pressed snugly into place in its seat. The ejector ring *D* is made to fit in the annular space between the die and punch and this member is fitted with four operating pins *E* whose bodies pass down through the base and rest upon the rubber attachment at *F* which is made up of a pair of $\frac{1}{4}$-in. steel plates with the rubber section between. The attachment to the base is by means of the $\frac{5}{8}$-in. shouldered stud which is tapped into the casting.

The blanking punch *H* of tool steel is bored out to form the piercing die and to admit the knock out *K* which has a shank passing up through the

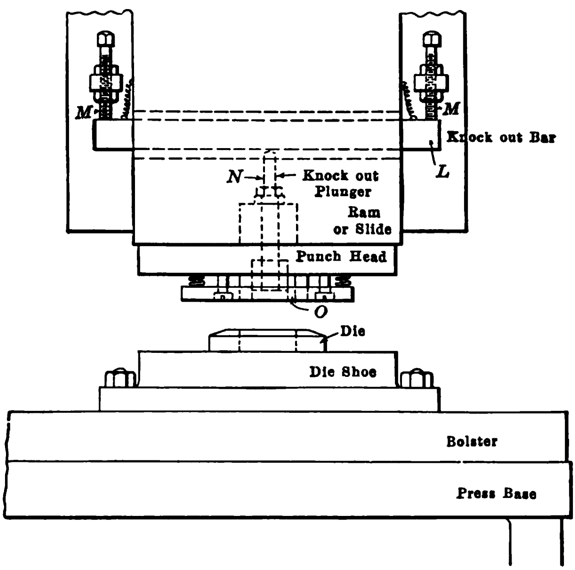


FIG. 134. — Application of positive "knock out"

punch holder with two check nuts at the top. For light stock a rubber spring or a steel coil spring at *I* may be made to serve the purpose of ejecting the center as punched out of the work by the piercing punch. With the extended shank on the knock out a positive action may be secured by the top of the shank on *K* striking a stop on the press guide when the ram ascends to the top of its stroke.

Positive Knock Out

One form of positive knock out is that shown by the sketch, Fig. 134. The horizontal bar *L* passed through a slot crosswise of the press slide is suspended by springs at the end and is adapted to rest with its upper surface against the top of the slot. When the ram is near the top of its stroke the top of the knock out bar *L* contacts with the two adjustable stop screws *M* carried by the press guide and as the bar *L* can then travel up-

ward no further, the result is that the ram continuing upward forces the top of the knock out plunger *N* against bar *L* and the slug is ejected from the upper die *O*.

A Small Gear Wheel Job

The photograph, Fig. 135, illustrates another form of compound die as applied to the blanking and piercing of a small nine-toothed gear which is made from $\frac{1}{16}$-in. sheet steel. The gear is $\frac{9}{16}$-in. outside diameter and the hole at the center is $\frac{1}{8}$-in. diameter.

The tools are of the subpressed type with two pillars at the back of die shoe and punch head. The details of construction are covered in the line engraving, Fig. 136.

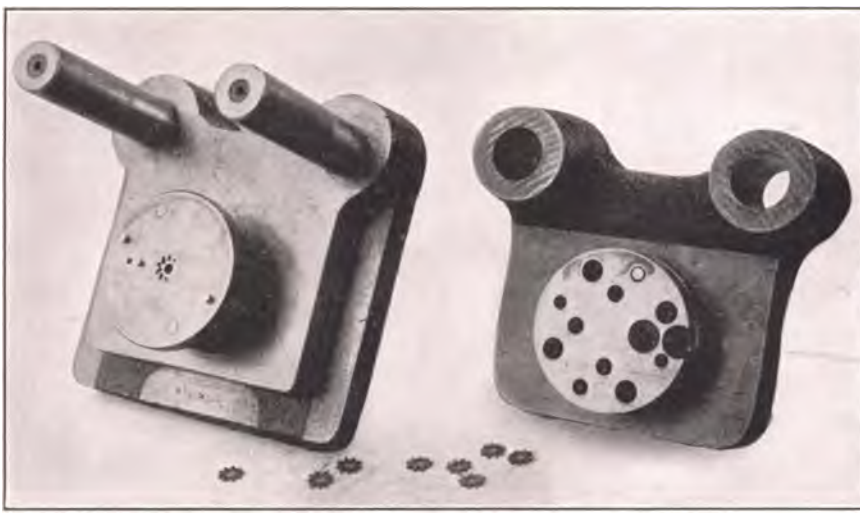


Fig. 135. — Compound dies for making a small gear

The blanking punch is located at *A* in the lower member of the set. The hole *B* at the center of this punch for the piercing die is relieved a short distance below the top as seen more clearly in the enlarged detail in this engraving, in order to clear the slugs more freely. The punch body *A* is let into the cast base and secured by screws and dowels. It is fitted with a stripper plate *C* which is made to the same tooth outline as the punch and which is actuated by the four pressure springs beneath at *D*.

The blanking die *E* is inverted and carried in the upper member of the set of tools. It is here secured in the same manner as the blanking punch *A* below and is bored out to receive the ejector *F* which is held in lower position by four small knock out pins *G* which pass up through the head and come in contact with the spring actuated plunger *H* at the top.

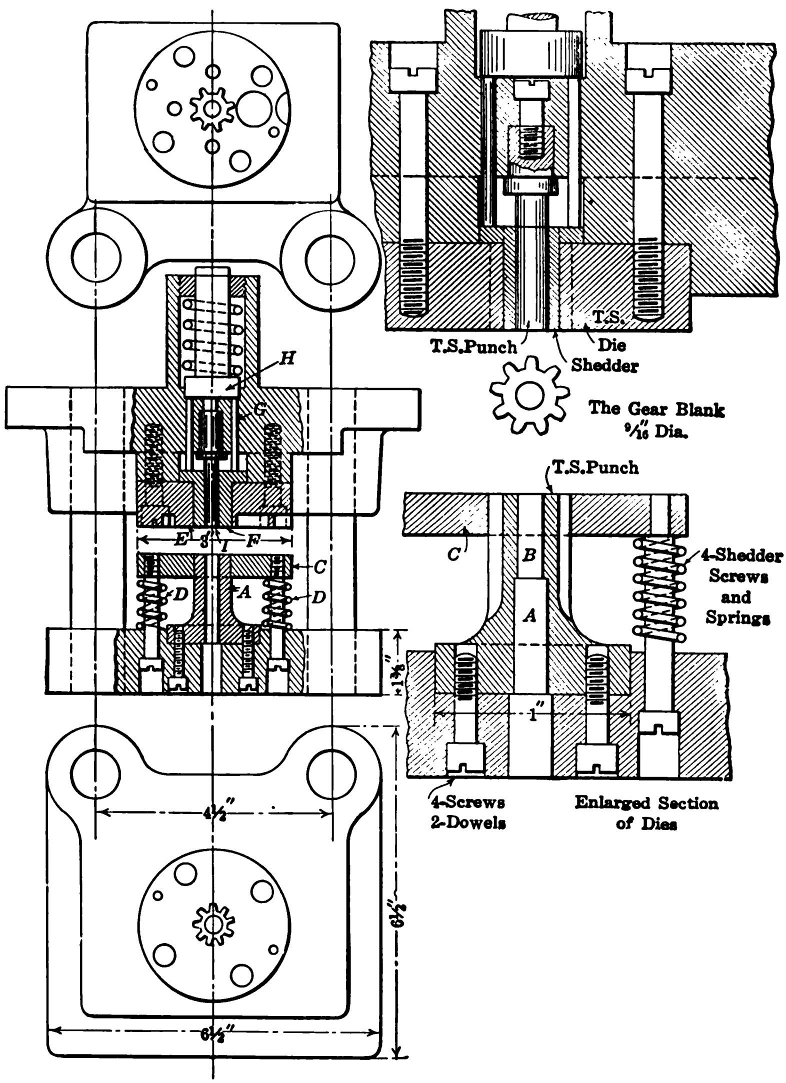


FIG. 136. — Compound dies for making a small gear

ACTION OF THE TOOLS

The piercing punch *I* fits through the center hole bored in the ejector and is formed with a shouldered shank fitted in the head as indicated. When the press slide descends the gear is blanked out in die *E* by punch *A*, and at the same time piercing punch *I* forms the center hole by punching the slug into the piercing die in punch *A*. When the dies separate by the upstroke of the press stripper *C* clears the blanking punch *A* of the stock

scrap and the knock out *F* ejects the work from the blanking die *E*. The slug from the piercing operation passes down through the die opening in *A*.

The punches and dies are of course of tool steel properly hardened, and the knock out pins *G* are of drill rod. The stripper and pressure plate *C* carries the stops and locating pins which serve as a gage for the stock. The die *E* at the top is counter-bored at two points on the center line to provide clearance openings for the gear blank as carried along through the dies by the movement of the strip of stock as it is fed forward for the production of successive gears. The gear as produced and knocked out of the blanking die is forced back into its place in the scrap by the action of the ejector or knock out *F* and is thus carried along with the material as it feeds along between the dies.

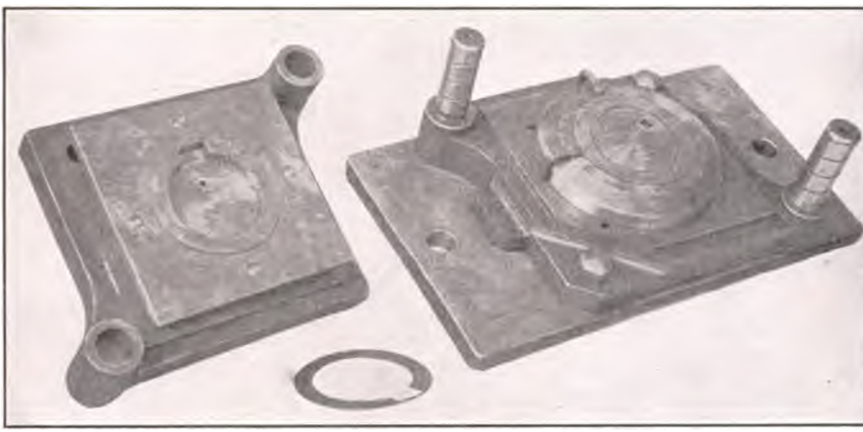


FIG. 137. — Dies for thin washer with keyway punched out

The special feature of dies of this character, where the work is ejected by the process shown and forced back into the opening in the scrap, has led to their being called in some places "cut-and-carry" dies.

WASHER AND KEY SLOT DIES

In general, the compound tools in Figs. 137 and 138 are quite similar to the washer dies in Fig. 131. There is however an interesting point of difference in that the dies in the former views are for making a thin washer or ring in which a key slot is pierced at the same time that the outside is blanked and the center punched out.

The view in Fig. 138 of the tools taken apart shows all of the members clearly and it is unnecessary here to enter into a prolonged description. It may be pointed out that the blanking punch and die and the piercing punch are held and located in their respective seats in the same manner as the corresponding tools referred to in connection with the set of dies in

Fig. 131. But the piercing punch is made up with the square extension at one side for producing the key way cut and similarly the interior of the blanking die is cut out for a key slot to correspond. Also the knock out for both tools is made with the key slot in the blanking die ejector and with the key extension on the side of the knock out in the piercing die.

The shedder springs and the rubber knock out device for the lower die are identical with the others already described. There is one further feature that should be noted here and it applies to the dies in Fig. 131 as well. This is the set of disks seen at the right of the stripper plate which are adapted to fit into the counter-bored seats for the ends of the compression springs which operate the stripper on the blanking punch. These disks are $\frac{1}{8}$-in. thick and their purpose is to diminish the depth of the

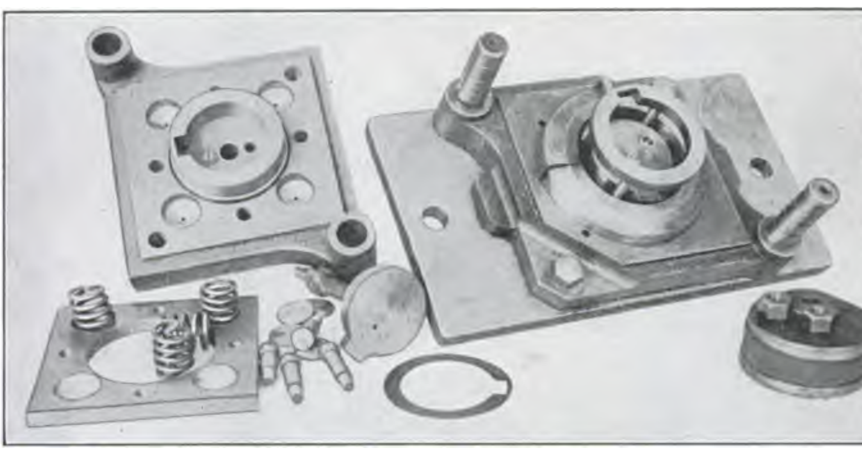


Fig. 138. — Showing construction of dies in Fig. 137

spring seats by that amount when the dies are new. After repeated grindings have shortened the dies by about the same degree or $\frac{1}{8}$ in. and the stripper has been adjusted accordingly, the disks are removed so that the springs then have practically the same distance between their opposing seats as they had at the outset, thus keeping a fairly uniform tension during the continued use of the dies.

These packing disks are shown in place in the sectional view of the other set of tools in Fig. 133 where they are designated by the letter *X*.

Larger Compound Tools

Still another interesting set of compound dies is shown by Figs. 139 and 140. These are for making a disk of steel plate about $\frac{1}{16}$-in. thick, having a large V-gap cut at one side and two rivet holes pierced along each edge of the gap. The center is punched out at the same time. General propor-

tions of the work are indicated in Fig. 141 and a good idea of the principle features of the dies themselves is presented by the plan and sectional views in Figs. 142 and 143.

The work is a circular blank about 6 in. across and the V at the side is about 30 degrees included angle. The piece is seen to the left of the group of die parts in Fig. 140. The blanking die is shown at A and the

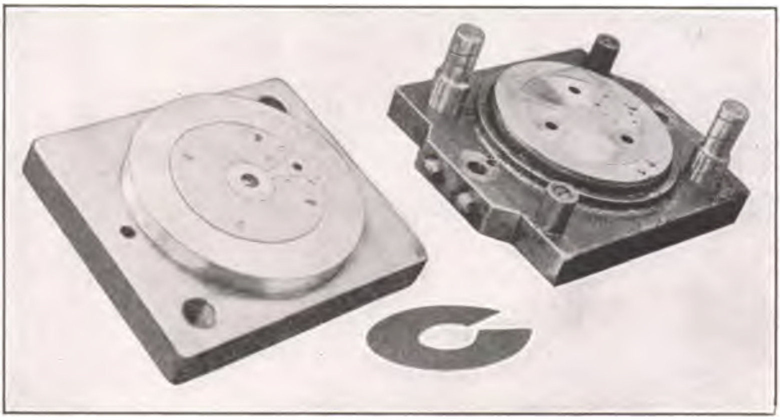
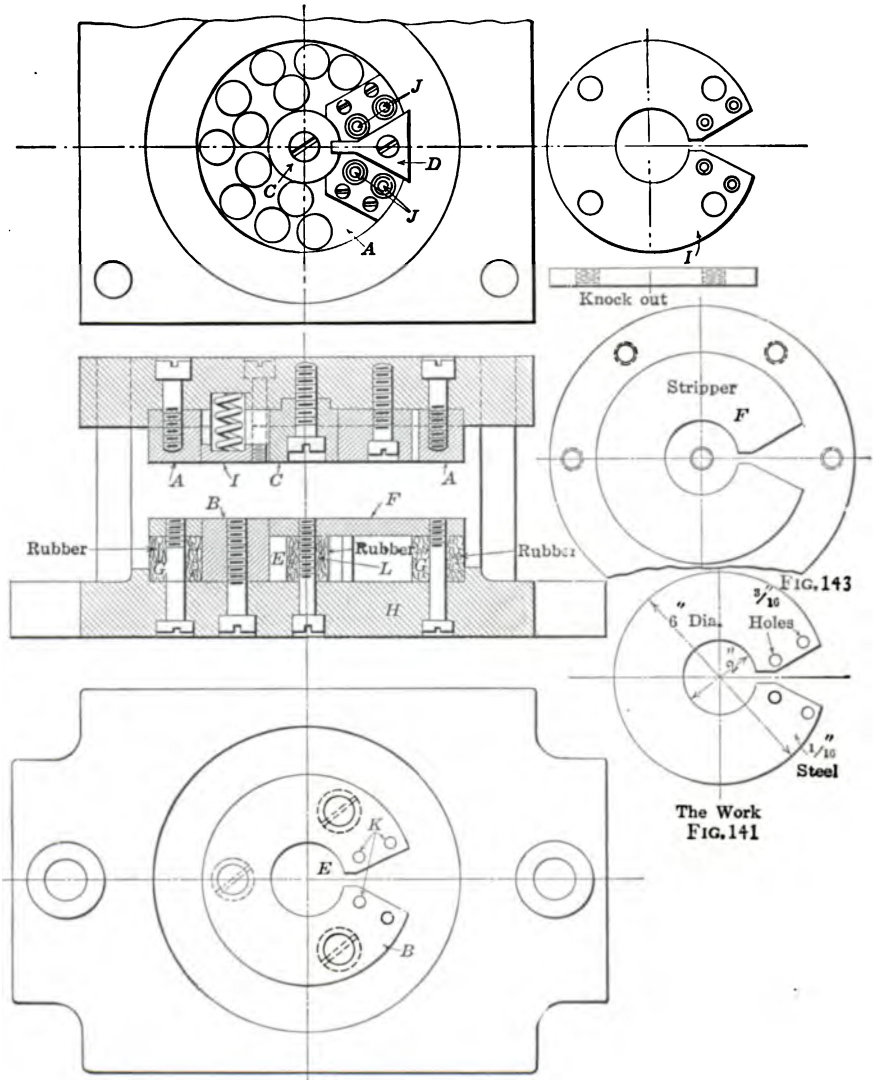


FIG. 139. — Another example of compound die work

FIG. 140. — The dies taken apart

blanking punch at B. The blanking die head is bored at the center for a seat for the piercing punch C and both the punch and the internal wall of the blanking die are slotted as indicated at D to receive the ends of the inserted piece D which blanks out the V-shaped opening in the disk.

The blanking punch is bored and ground out at the center for a 2-in. hole E to form the piercing die. The punches and the die are of tool steel carefully hardened and finished and secured by fillister head screws and dowel pins to their respective holders.



FIGS. 141–143. — Construction of dies shown in Fig. 139

STRIPPER AND KNOCK OUT

The stripper and pressure pad which encloses the blanking punch *B* is operated as at *F* against a thick rubber ring *G* which is seated in a large recess faced out in the shoe *H*. A series of fillister head screws passing up through the ring and into the stripper retain the latter in position.

The knock out disk *I* for the blanking die is held by screws from the top

of the head and is actuated by a series of stiff springs to eject the work from the die when the latter rises from the punch. The four small rivet hole piercing punches *JJ* are inserted in blocks which are fastened by screws and dowels in the interior of the blanking die as seen in the drawing. These small punches and their holding blocks are also shown in place in the die in Fig. 140.

The die holes for the piercing of the small holes are shown at *KK*, Fig. 142, and the corresponding holes in the knock out *I* are plainly visible in the photograph, Fig. 140.

Both the stripper *F* and the knock out *I* are shown by detail sketches in Fig. 143. The central portion of the stripper is attached to the main

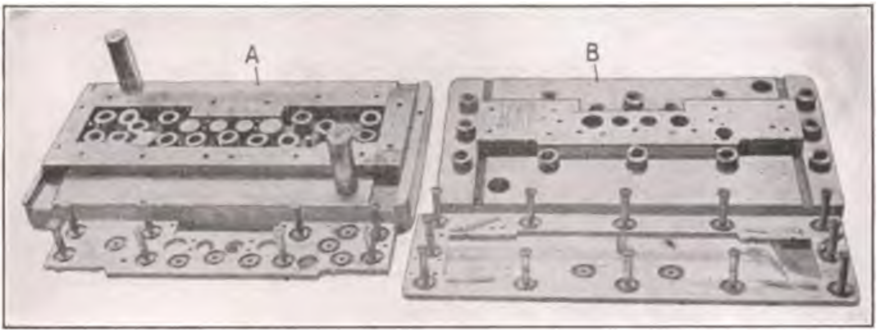


Fig. 144. — Large compound dies for blanking and piercing a rectangular plate

ring by a narrow tongue as indicated, following, of course, the outline of the piercing punch at this point. The projecting portion of the stripper is therefore provided with a separate rubber spring at *L* and a fillister head screw is tapped in from the under side as with the other portions of the stripper ring.

A Rectangular Piece of Work

Another large compound die is represented by Fig. 144. The tools here are for producing the steel plate in Fig. 145 which is afterward bent and formed to the shape in Fig. 146 for a casing for certain mechanism of a coin register. The stock is $\frac{1}{16}$-in. thick and the piece is cut out approximately to length and width before it is placed in the compound dies for trimming to correct shape and piercing of the various holes.

There are a number of different sizes of holes among the number pierced and some of them are rectangular for the staking in of other members. The largest round holes are 1.082-in. diameter, the smallest 0.125 in. Four small tongues are formed along one edge in these dies and the $4\frac{5}{8}$-in. gap at the front is also cut out.

The half-tone engraving of the tools gives a pretty clear conception of

the manner in which the dies are made up. They are of sectional construction, the blanking die *A* being built up of tool steel sections let into channels planed in the base and there held by fillister head screws and dowels. The piercing punches are inserted into place in the die base and the larger ones held by a screw from the bottom. The smaller ones are pressed into their holes.

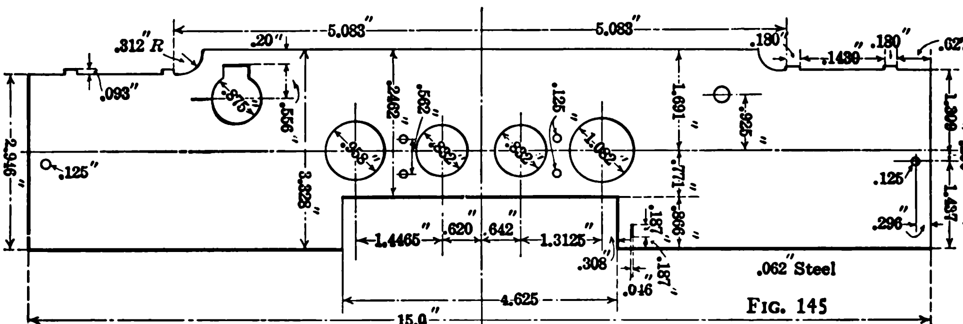


FIG. 145
The Piece as it comes from the Dies

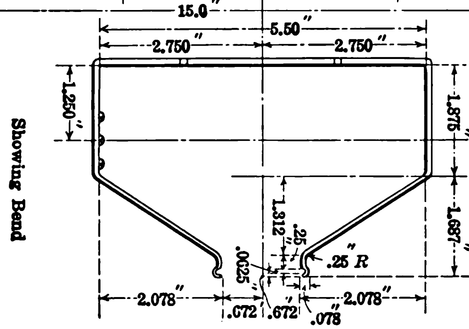


FIG. 146
The Work after Bending

FIGS. 145–146. — The work blanked and pierced in large compound die

The blanking punch with its openings constituting the piercing dies is seen at *B*. This member is also sectional and the locations of holding screws and dowel pins will be noticed in the view. The stripper for the punch is shown immediately in the front of that member and the knock out for the blanking die *A* is likewise seen in front of the die base. Both knock out and stripper are bottom side up in order that the provision for operating springs may be visible.

For the die knock out there are 15 of these springs, for the punch stripper there are 12 in all. The seats for the ends of the springs are neatly formed by hollow milling in a series of annular channels which are $\frac{1}{8}$-in. deep and of the proper diameter outside and inside to accommodate the spring dimensions. This gives a form of spring seat that holds the spring without possibility of its tilting and thus maintains it in most effective position at all times.

The underside of the stripper is shown fitted with four flat springs.

These act upon the lower ends of a set of gage pins or stops which normally extend up through the face of the stripper and form setting stops for the work. Upon the punch passing down into the work the spring pins are depressed accordingly and rise to original position when the punch again ascends.

Electrical Work Dies

One of the most common uses of the compound die is in connection with the blanking and piercing of parts for electrical apparatus, and a set of tools of this nature are shown by the engraving, Fig. 147.

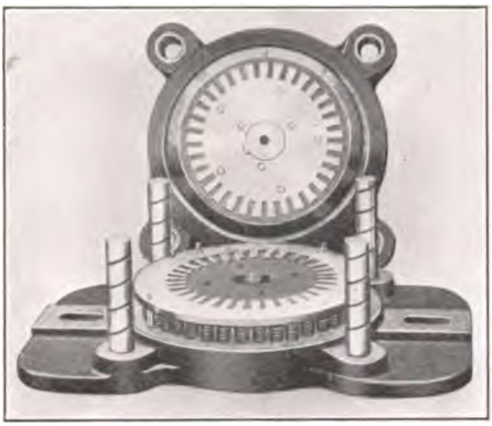


Fig. 147. — Armature disk punch and die

These dies are for armature disks and this is an example of the advantages of such tools in producing perfect concentric work which is essential with this class of material. The dies produce a disk with 32 notches and the close fitting stripper ring for the punch is controlled by the same number of springs, which, with the guide pins, are clearly represented in the lower member of the set.

Dies of this type are employed for making various designs of disks, some with external notches, others with notches inside. Figs. 148, 149 and 150 show three forms of such rings or disks as commonly blanked and pierced. Electrical work, like typewriter manufacture, adding machine and calculating machine work and so on, requires extensive application of many interesting forms of dies and certain examples of compound as well as plain dies for these lines of manufacture will be referred to on other pages.

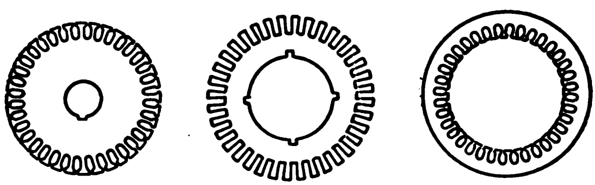


Fig. 148 Fig. 149 Fig. 150

Figs. 148–150. — Methods of notching disks for electrical machinery

A Stator Punching Die

It may be of interest here to show a compound die for a stator punching which is a typical form used by one of the largest manufacturers of electrical equipment. The sketch, Fig. 151, gives an outside and part interior view of such a die with the parts designated by name.

The tool steel die ring is secured to the upper half of the tools and blanks out the work. The lower half serves as the blanking die. It has a stripper plate resting on springs and this removes the material outside of the punching, that is the corners and margin. The punches for the slots are set into the upper die plate and there is also a guide plate that serves to hold the punches in position instead of leaving them supported at the ends only. In back of the punch shoe there is a member known as a knocker plate which is set into a recess with sufficient clearance to allow of sliding along the axis up and down. This plate is connected with the upper stripper plate or knock out by screws and knock out pins. In operation, after the stator punching has been made and the upper die rises, the outer scrap, of course, is lifted by the stripper on the lower punch, the tooth scrap falling through the lower openings and the punching being carried up by the upper die until, when the latter is near the top of its travel, a stationary pin strikes the knock out plate and releases the punching.

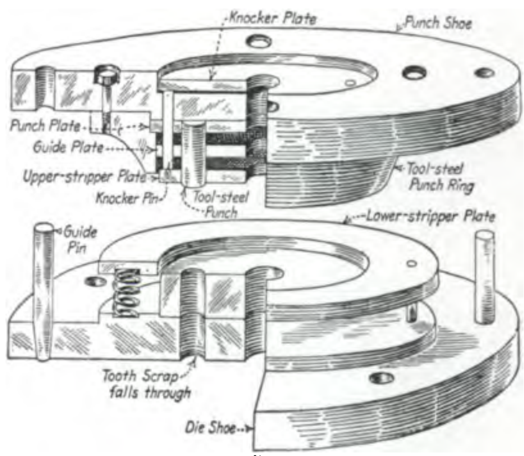


Fig. 151.—Compound dies for stator punchings

It is customary with these tools to harden the die in all cases but to leave the punch soft for dies on such punchings as just shown, to facilitate upkeep and repair.

Limits in Variation

The accuracy with which such dies are made and set up in the press has much to do with the amount of burr found on the work and it is desirable that definite standards as to the amount of variation permissible should be fixed upon and the tools then held accordingly. The limits established by the firm referred to and to which punches and dies are held, are as follows for stator and rotor punchings: small round hole dies are to be kept within plus and minus 0.002 in.; larger round hole dies within

plus and minus 0.003 in. Allowance for outside diameter of ordinary punchings made with round hole dies from 6 to 12-in. diameter is -0.004 to $+0.006$ in.; for 12-in. diameter and up -0.005 in. to $+0.006$ in. For rotor and stator punchings made with compound dies the following limits are allowed: From

1 to 15 in.,	$+0.002$ in.	to	-0.004 in.
15 to 20 "	$+0.002$ "	"	-0.005 "
20 to 25 "	$+0.003$ "	"	-0.005 "
25 to 35 "	$+0.004$ "	"	-0.006 "

The allowance on the bore for rotor punchings, shaft fits, is between $+0.001$ and -0.003 in. for all diameters of bore. For pole punchings on direct-current machines the variation in height, that is the difference between inside and outside radius on the individual punching, is allowed to be $+0.003$ in. to -0.002 in. for 1 in. to 4 in. high, and $+0.005$ to -0.002 in. for 4 in. and above.

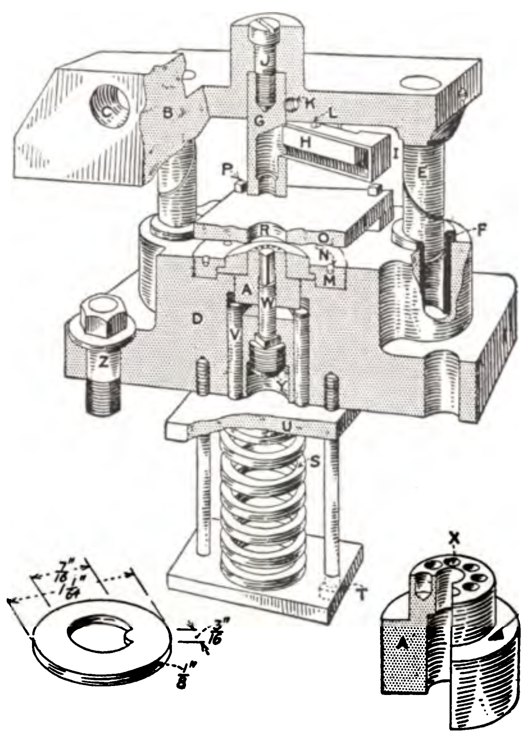


FIG. 152. — Lock washer tools

A Special Form of Knock Out Bushing

One more example of compound die design is included here. This is a set of tools for making a lock washer from $\frac{1}{8}$-in. steel scrap. One of the features of the die is the knock out bushing *A*, Fig. 152. This bushing is shown to larger scale in the detail at the lower corner of the engraving. The bushing is so made that it is impossible to plug up the die as long as the operator gives attention to his work.

The knock out bushing has a series of holes *X* drilled in its face and these are known as "signal holes" for they will always show whether the last blank has been discharged or not. Should a washer stick in the die and cover the signal holes, the difference between the plain face of the

washer and the drilled face of die A at once becomes apparent to the operator who can then remove it before tripping the press.

The punch shoe B is of cast iron and fits the press ram to which it is bolted. The die base D is made of cast iron and aligned with the punch by the steel guide pins E and bushings F. The blanking punch G is of hardened tool steel. This punch is counter-bored above the piercing opening for slug clearance and has an opening at H through which the slugs are discharged into the chute I, which is fastened to the punch shoe by the screw L and so arranged that the slugs will fall clear of the die. The punch is held by the screw J and kept from turning by a tapered pin at K.

The blanking die is a bushing held in place by the threaded bushing M which is seated and secured by a spanner wrench fitted to holes N. The stripper O held by cap screws P is open in front to allow the operator greater freedom and better view while using the die. The opening under the stripper at R is necessary in order to let the washer slide off the die when blanked, the press being inclined at an angle of 45 degrees.

The bushing A is made of tool steel hardened and ground to size and serves as a knockout for the blanking die. Special care must be taken at the time of setting up the die to get the proper pressure on the pad A by the correct adjustment and tension of the spring S and the nuts T.

The pressure is transmitted to the knock-out bushing by the plate U under the die and the hardened pins V. The perforating punch W has a square head to prevent it from turning in the die and is securely seated by set screws Y. The die is fastened to the bed of the press by the cap screws Z.

CHAPTER V

CUTTING-OFF DIES OR PARTING TOOLS

In addition to the blanking processes already illustrated in preceding chapters, there is another method by which blanks are produced which may well be described before the subjects of trimming and shaving dies are taken up. This method makes use of one of the simplest forms of press tools, the cutting off or parting die, sometimes known as a shearing die, as in its primary form it is merely a set of tools with a straight cutting off punch shearing past a similar die as in Fig. 14, Chapter I.

With the cutting off or parting die the strip of material operated upon is of the width wanted for the work and the production of the blank consists in cutting the stock to the requisite length, this length being gaged by a stop set as in the case of various other types of dies.

The cutting off tool is not necessarily confined to simple shearing of a straight edge across the piece, for it is quite as adaptable to the cutting of a

FIG. 153. — A piercing and cutting-off die

curved end or other form for the work and in fact is extensively employed on pieces of this sort. Furthermore it is often combined with piercing and other tools to sever the blank from the end of the strip of metal after other operations have been accomplished in dies of the progressive or follow type.

PIERCING AND CUTTING-OFF ARRANGEMENT

A set of tools of this character for piercing several holes in the material and cutting to length are shown by Figs. 153 and 154. The blank made is in this instance 4 in. long by $2\frac{1}{2}$ wide with five $\frac{1}{4}$-in. holes spaced as represented and a $1\frac{1}{4}$-in. hole punched near the center. The material is $\frac{1}{16}$-in. cold rolled steel.

The photograph and drawing show most of the tool details clearly and a brief explanation will answer all purposes. The stock is the width required for the work and the strip of metal is held true against the guide at the back of the die by the projecting handle of the bent member *A* which

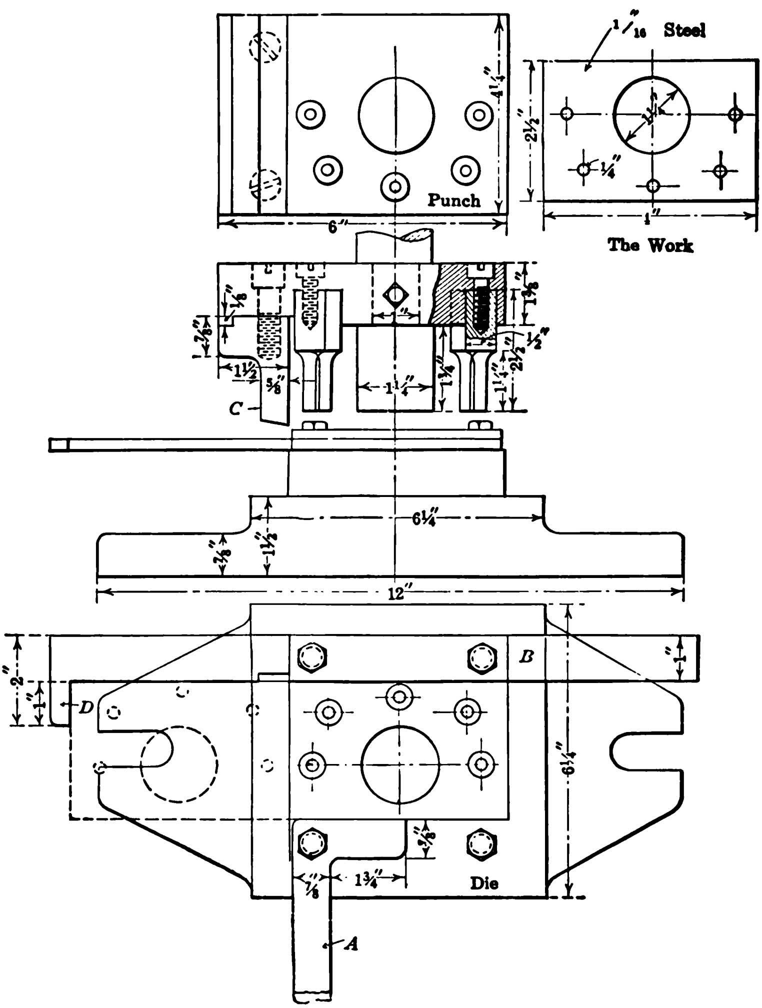


FIG. 154. — Piercing and cutting-off dies

forces the work squarely against the guide *B*. The method of locating the different punches for piercing and the cutting-off punch *C* will be seen from the drawing.

The cutting-off punch is, in this case, shown with a relieved or backed off edge of about 8 degrees to give freedom of cut and it might with equal

ease be made with a sheared edge from front to back if the metal operated upon were sufficiently heavy to necessitate it.

The end of the stock, as it is passed through the stripper, is first trimmed off by the cut-off punch and the strip of metal is then advanced against

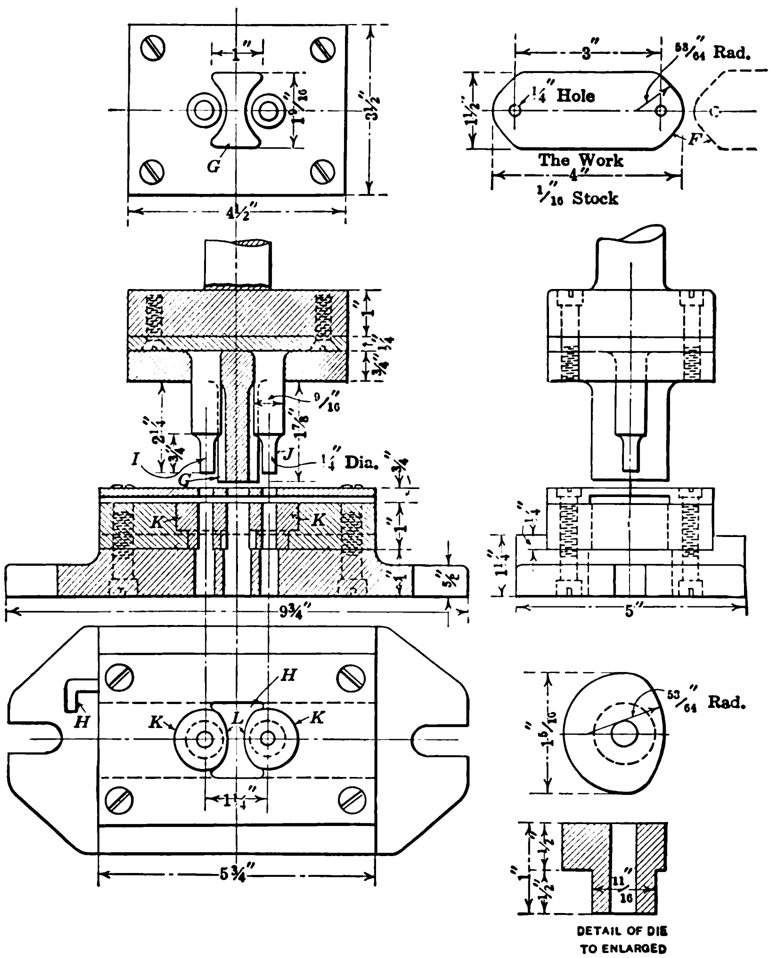


FIG. 155. — Cut-off dies for round ends

the stop D for cutting off to length. The first down stroke of the punch has already pierced the work and the first cut-off or trimming of the end prepares the leading end so that each following down stroke pierces the holes through the material while the preceding blank is severed by cut-off punch C.

There are numerous combinations of piercing punches and parting

tools on work of this general character and various methods of securing the punches to the holder. The method illustrated is only one of several satisfactory ways in which they may be inserted and fastened in place.

End-forming Parting Tools

The dies in Fig. 155 represent an example of a set of cutting-off dies which at one stroke pierce holes in the ends for adjoining blanks and cut the two pieces apart, at the same time shaping the ends to the round form *F*, shown at the upper corner of the drawing. The tools are arranged with a centrally located cutting-off punch and a piercing punch at either side.

As indicated at *G*, the central punch is in the form of a concave sided tool with section suited to the curves required on the ends of the pieces to be cut off from the strip of stock. The material worked is $1\frac{1}{2}$-in. wide and the punch is $\frac{1}{16}$ more or $1\frac{9}{16}$ in. from front to back. The piercing punches are located to pierce a $\frac{1}{4}$-in. hole at each side of the parting punch.

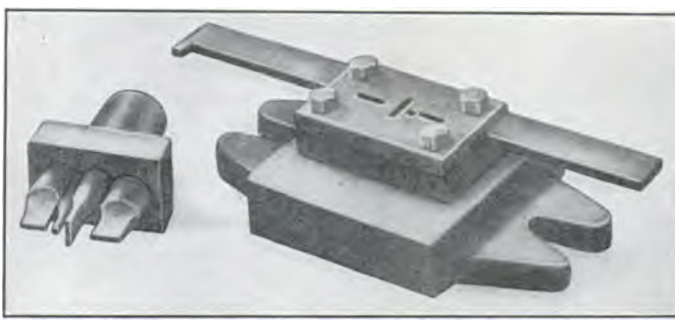


Fig. 156. — Slotting and cutting-off tools.

The strip of material to be used for the work is fed past the edge of the cut-off punch *G* and the first stroke shapes the leading end of the work and pierces the hole in that end. Then the work is advanced to the gage *H* and the next stroke of the slide causes the punch *I* to pierce the second end of the first piece while the punch *G* cuts it off and shapes the end of the next piece and the punch *J* pierces the $\frac{1}{4}$-in. hole for that piece. So for each succeeding operation of the punch a piece is completed and cut off.

The dies *KK* are inserted, as they are of the button type, and each is finished to a diameter of $1\frac{5}{16}$ in. with the front edge at *L* ground to the longer radius required or $\frac{53}{64}$ in. This facing of the die to the radius given at the point of cutting only, makes it possible to use a smaller diameter of body for the die and when the cutting portion becomes worn the die may be pressed out of its seat, a new portion of the edge ground to the radius of $\frac{53}{64}$ inch and the die pressed back into new position for continued service.

A Slotting and Cutting-off Job

The tools in Figs. 156 and 157 are for a somewhat similar piece of work to that just shown except that the work in Fig. 157 has a slot pierced in each end besides the round hole pierced at one end only. The ends are cut off square and the work measures 7 in. in length. It is cut off from $\frac{1}{16}$-in. steel $\frac{1}{2}$-in. wide.

The punches are placed as represented in the plan and side views. The

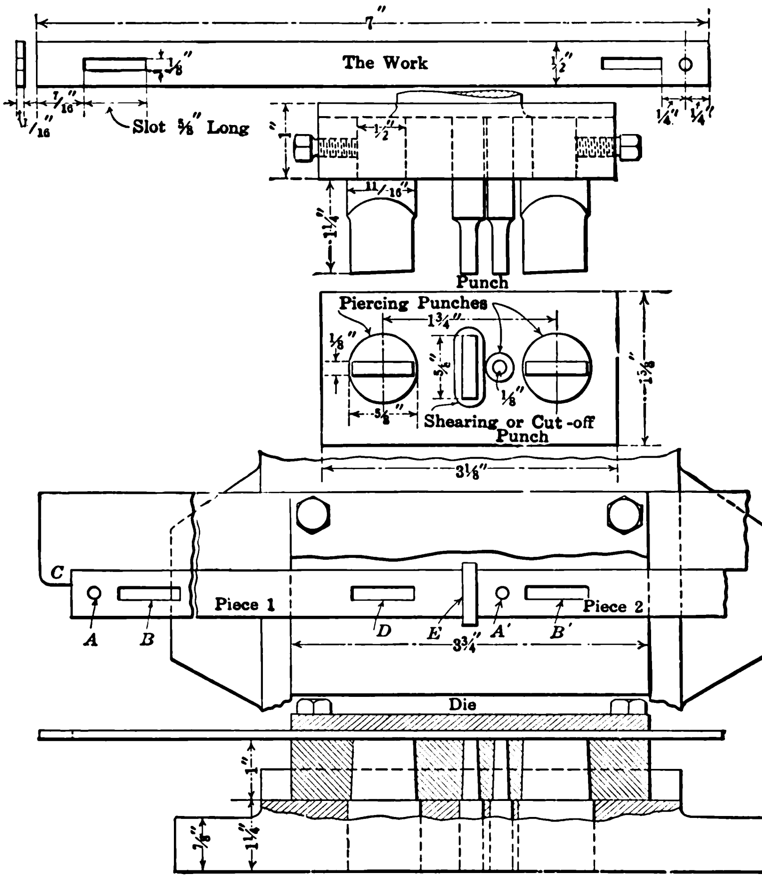


Fig. 157. — Slotting and cutting-off tools

slotting punches are sheared along the edge to give free cutting action in piercing out the rectangular opening. They are placed $1\frac{3}{4}$ in. apart on centers, and the cut-off punch is located midway between.

The work is produced as indicated by the plan view of the die proper. The stock is first advanced past the cut-off punch which shears off the end of the strip and the round hole *A* and slot *B* are pierced at the same stroke. Then the work is fed along to the stop *C* and the next down stroke of the

press pierces the slot D at tne opposite end of the piece and also cuts the piece off at E and pierces hole A' and slot B' in the next length at the same time. So each following stroke of the press completes a piece.

The stock guide under the stripper holds the stock closely sidewise and assures its being pierced and severed squarely without twisting to one side.

Parting Tools for a German Silver Bar

The set of dies in Figs. 158 and 159 are for cutting off german silver bars to form the decimal pointer bar used on a calculating machine. One of these pieces will be seen in front of the dies in Fig. 158 and detail dimensions are given in Fig. 160. The material from which the bars are cut off is 0.140-in. wide and 0.078-in. thick. The ends are formed to a true

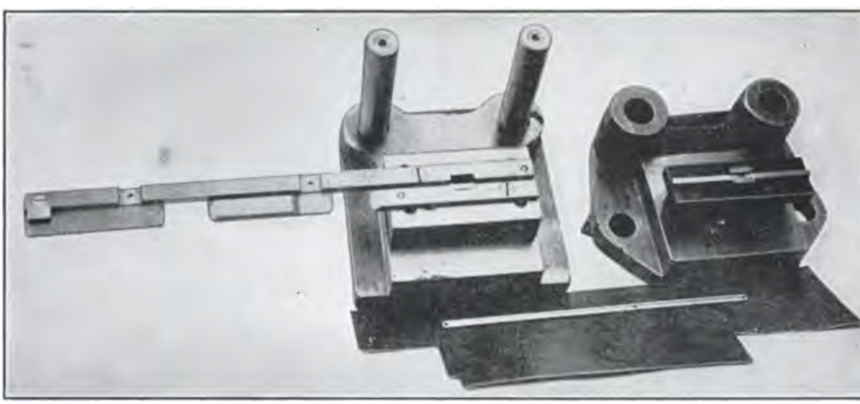


Fig. 158. — Parting and end-forming dies

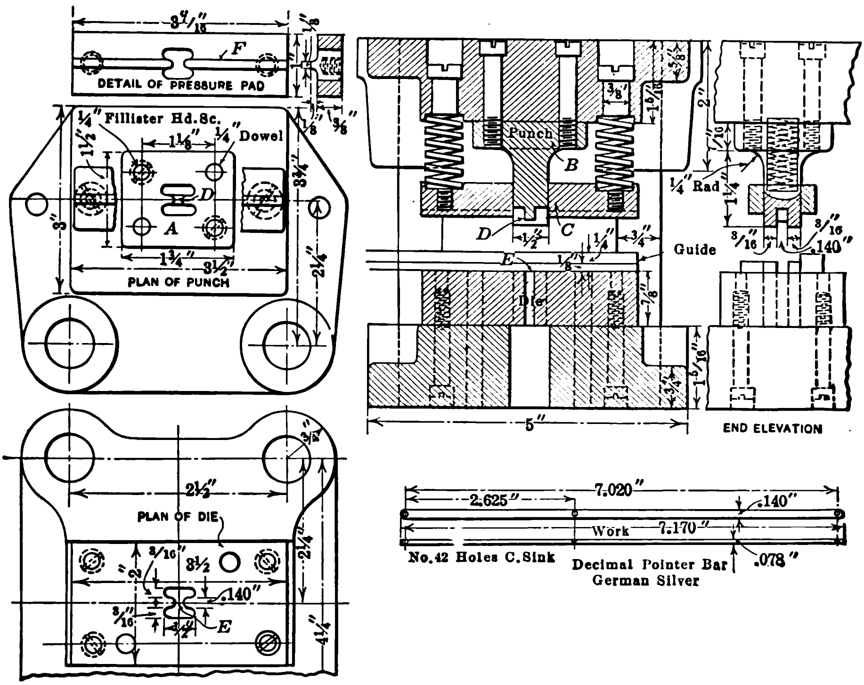
half circle in the cutting-off process. The three small holes in the bar are afterward drilled and counter-sunk as shown.

The punch is in the form of a letter "H" as shown at A, Fig. 159, finished on the end of a square shank with broad base B secured by two fillister head screws and dowels to the head. This punch fits closely through an opening in the pressure pad C and the lower end of the punch is guided in the oblong die openings, while the central or cutting portion of the punch at D cuts the work apart and produces the rounded ends on the material. The small slug punched out to sever the work is forced down through the central die opening at E in the same manner as a slug from a piercing operation.

The narrow bar to be cut off is placed in the slot in the guide at the top of the die, this guide extending to the left as in Fig. 158 to support the projecting work and act as an end stop for determining the length cut off. This guide is attached to the die by two counter-sunk head screws and its position is maintained by these screws and by a pair of small dowel pins.

The die itself is attached to its base by four fillister head screws tapped in at the corners from the bottom and two dowels are located at diagonally opposite positions as seen in the photograph.

The pressure pad is formed with a central ledge or projection at *F* which



FIGS. 159–160. — Details of parting dies shown in Fig. 158

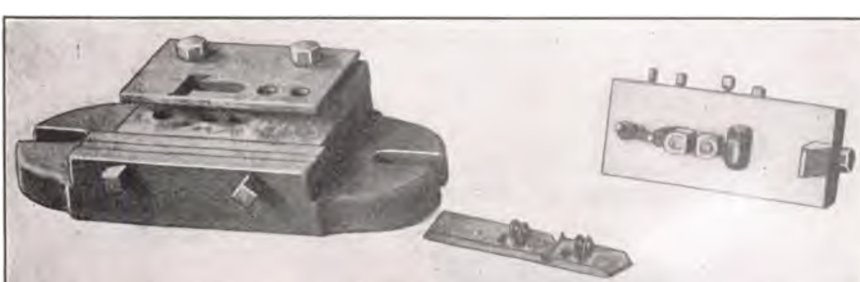


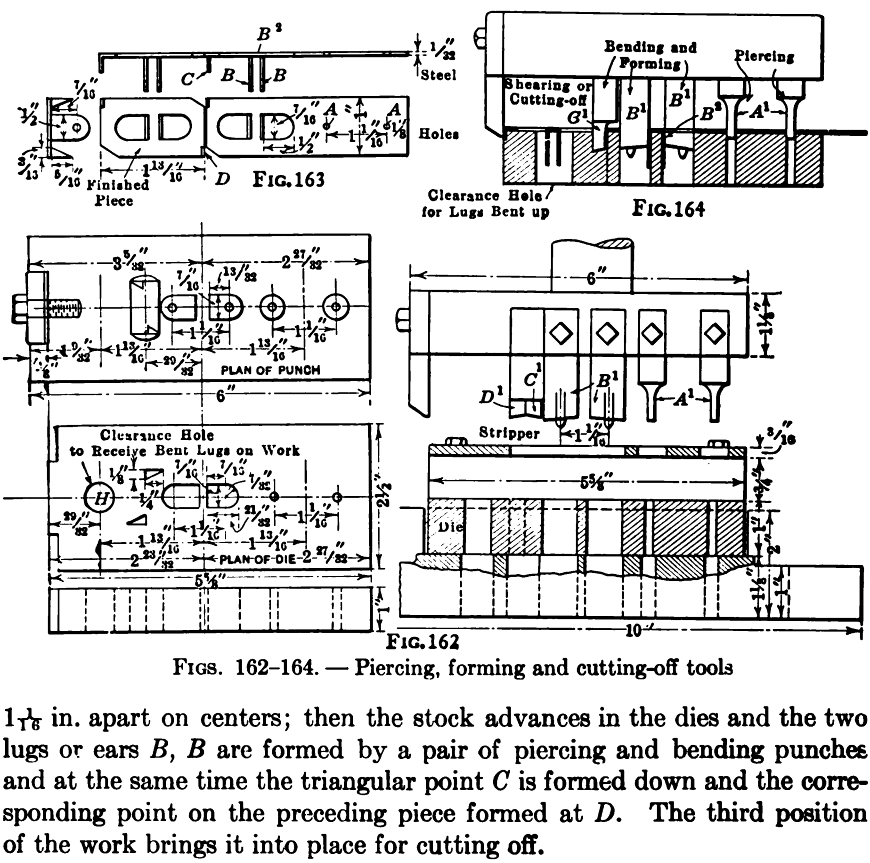
FIG. 161. — Progressive piercing, forming, and cutting off dies

bears directly upon the narrow strip of work during the cutting-off operation. This bearing surface extends the full width of the die face or $3\frac{1}{2}$ in., except for the one-eighth portion at the center which is cut out to clear the cutting portion of the punch.

Piercing, Forming, and Cutting Off

The half tone, Fig. 161, illustrates a set of dies of the progressive order, for piercing, forming the lugs, and cutting off the piece shown in the foreground of the photograph. As represented the completed piece is shown resting in contact with a strip of metal pierced and formed for the lugs and ready for cutting off.

The tools are shown, also, in the line drawing, Fig. 162, and the work itself in Fig. 163. From the latter sketch it will be seen that the strip of steel is first pierced for the two holes A, A, which are $\frac{1}{8}$-in. diameter and



FIGS. 162–164. — Piercing, forming and cutting-off tools

$1\frac{1}{16}$ in. apart on centers; then the stock advances in the dies and the two lugs or ears B, B are formed by a pair of piercing and bending punches and at the same time the triangular point C is formed down and the corresponding point on the preceding piece formed at D. The third position of the work brings it into place for cutting off.

The order of operations is very clearly indicated in the sectional view, Fig. 164, where the two piercing punches are shown at $A'A'$ for the $\frac{1}{8}$-in. holes; the two cutting and forming punches at $B'B'$ for the lugs or ears B; the bending punches at C' for the pointed ears C and D; the cutting-off punch at E' for severing the finished work.

The sectional views and plans in Fig. 162 show most of the important

dimensions and the method of placing punches and other details. The punches $B'B'$ for cutting and bending down the projections or ears B are sheared or beveled from the rounded edge back to the heel so that the cut will be started at the semi-circular end of the ear, and the width of the punch back from this edge to the heel is $\frac{1}{32}$ in. under the dimension for the die or a difference equal to the thickness of the stock, so that the punch will have a bending action on the work and carry the material down over the corner as at B 2 and thus form up the lug as indicated. The punches $B'B'$ are provided with pilots to center the work from the two pierced holes put through by punches $A'A'$

The punches $C'D'$ are sheared to cut from opposite corners to start the cut on the triangular points C and as they have the same clearance of $\frac{1}{32}$ in. between the back of the punch and the edge of the die they bend the point down in the manner shown.

The hole at H is a clearance space for the ears BB after these are formed and the material fed along for the next cut. The view in Fig. 164 shows the two projecting portions extending down into this opening. At the same time the two triangular points bent down at C, D, pass over the end of the die at the left where the shearing punch cuts off the completed piece of work.

CHAPTER VI

SHAVING DIES AND THEIR APPLICATIONS

Shaving dies provide a means of finishing blanked or pierced parts very accurately and with a perfectly smooth unbroken edge. In spite of their serviceability in this direction they are used only to a limited extent in the majority of shops doing press work and in many they are practically unknown. Yet their more general adoption for work requiring fairly close limits of accuracy would result, in many cases, in a considerable degree of economy in the long run and the product throughout would be turned out to greater advantage, so far as concerns correctness of outline and quality of finish.

Their application, however, means, in most instances, the running of the blanked work through a second operation and this naturally has much to do with their apparent neglect in various directions. Still, on the other hand, where accuracy is to be adhered to in the pressed parts and smoothness of contour is also an essential, the shaving die would make it possible to attain the desired results with less attention to the quality of the blanking dies and correspondingly more latitude might be permissible in the upkeep of the latter tools.

For, where the piece is to be shaved after blanking or piercing, the exact size to which the work is produced in the first operation need not be given the close attention that would otherwise be required, for a slight amount of wear in the dies will not affect the completed piece as the shaving tools will bring it to size. And this means that in the making of the blanking tools originally, a little more leeway is permissible.

Uses on Heavy Stock

As heavier gages of stock come to be considered, the shaving die becomes almost a necessity if best results as to size and finish are to be expected. For the heavy stock imposes severe duty upon the blanking dies with corresponding degree of wear, and the thick edge of the blanked metal is apt to show a quality of roughness that is oftentimes unnoticed with lighter gage material. The sharpness of the corner is lost and the edge may assume an appearance of having been swaged in the blanking process. Also the cut edge may be rough and torn, a condition likely to be aggravated appreciably with certain grades of stock of heavy gage.

Some instances, where shaving operations are of prime importance, are as follows: Small toothed wheels where accurate surfaces are required for the gear tooth curves and smooth edges are essential. Small levers and rocker arms, etc., where certain contact points or bearing surfaces must be exactly finished in relation to other portions of the blank. Toothed segments and sectors where the conditions are similar to those pertaining to gear wheels as noted above. Certain pierced members requiring exact relationship between, say, a cam slot or a central opening in respect to the external surface. Here an internal shaving process is required for the pierced openings as well as for the blanked exterior.

Occasionally a blanked piece has to be shaved only at, say, one end, as for a rounded bearing point or a short contacting projection. In such cases the shaving dies may be made to operate only on the limited section where special qualities of accuracy and finish are desired. In such instances the shaving tools approach in function certain classes of trimming dies where the action of the tools is to cut away a small amount of material at some point on the edge of the work to change the form as blanked to the modified contour desired, as, for example, in trimming a rounded lug or shoulder to a "V" or other form. Usually, however, the trimming die has a considerable amount of material to remove and is thus differentiated from the shaving die which, as its name implies, takes only a very thin cut, a few thousandths at the most, on a side. In fact the amount left for shaving is sometimes divided between two cuts in first and second shaving dies and the latter is then required to remove even a smaller amount of material than is generally left for the single shaving operation.

Shaving Tools for a Gear Wheel

As an illustration of an accurate set of shaving dies, Fig. 165 is presented herewith showing the application of the double shaving principle, two sets of shaving dies being included in the equipment with the work of shaving divided between them; the amount left for the second shave is one-half that taken off by the first shaving dies. While there are as stated two shaving operations on the blank, the shaving tools are essentially the same in construction as a single shaving set would be, the sole difference being in respect to the diameter of the dies which in the present instance allow for the taking of the two cuts which, with the single shaving die generally used, would be confined to one cut only. This set of dies has been selected as the first illustration in the present chapter for the reason that the work produced forms a characteristic example of the class of parts to which the application of shaving dies is especially advantageous.

The blanking tools are seen to the left in the half-tone and no special description is required as they are of practically the same design as the set of wheel dies illustrated by Fig. 36 in Chapter II. The blank produced is

a ten-tooth wheel punched out of 0.050-in. half hard steel stock. The outside diameter of the gear wheel is 0.751 in., the depth of tooth 0.139 in. The piece is used on a calculating machine and thirteen wheels are required for each machine.

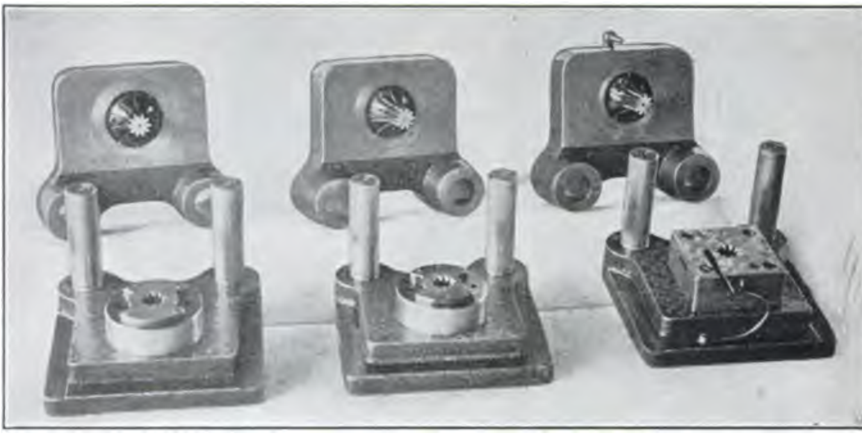


FIG. 165. — A set of dies for blanking, and shaving a small toothed wheel

THE SHAVING DIES

The two sets of shaving dies are alike except for the slight difference in diameter of punch, die opening, and nest. The sketch, Fig. 166, gives the details of construction with a few important dimensions. The die proper is of tool steel finished to 3 in. diameter, hardened, and finally secured by screws and dowels to the shoe or base. To this die is attached the nest, or "set edge," as it is sometimes called, for locating the work over the opening in the die.

As the shaving die is used expressly for securing accuracy in the work, as well as smoothness of contour, it is desirable to make the interior of the die straight instead of with the half degree clearance on a side commonly found in blanking dies. At the same time the difficulties commonly encountered in working out such a die opening with perfectly straight sides for the full depth of one inch or more generally results in the adoption of a compromise on this point and the practice in various shops is generally to work the die out straight for a depth of $\frac{3}{16}$ to $\frac{5}{16}$-in. dependent upon the thickness and nature of the material and then clear the die below the straight portion.

It is often found at the die maker's bench that the attempt to produce a perfectly parallel die opening from top to bottom results in a bell-mouthed hole instead of a straight one; and while, in various instances where special requirements demand it, straight dies can be and are regularly produced,

it is usually considered wiser and more economical practice to limit the straight portion of the opening to the amount specified above and clear the remainder of the depth by giving each side the customary one-half degree taper. This course naturally shortens the life of the die as compared with the probable working period through which it might be used if

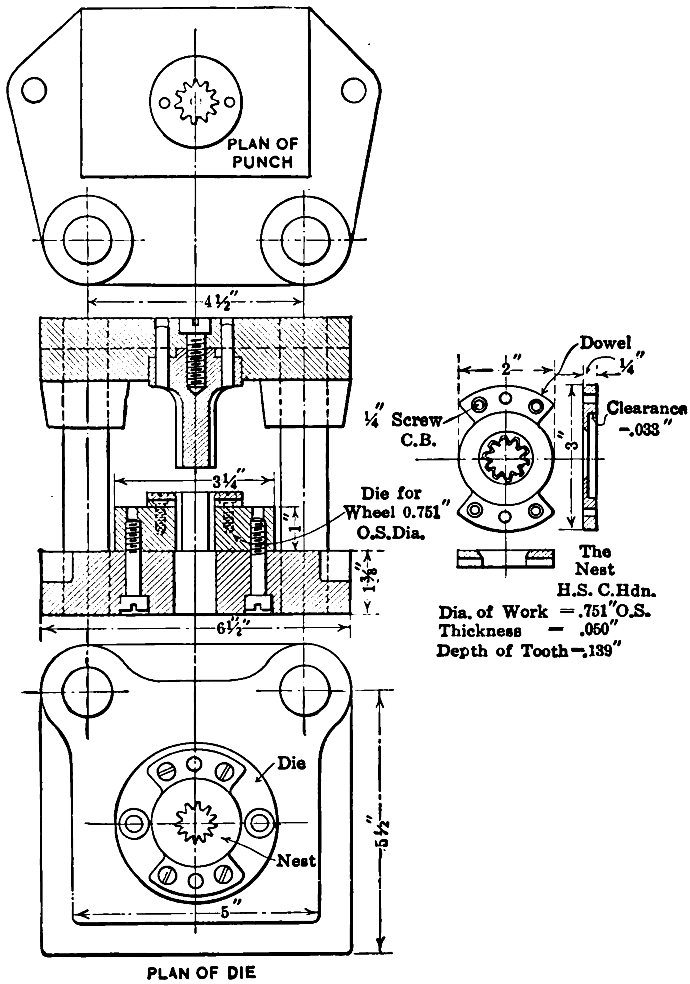


FIG. 166. — Shaving dies for small gear

made with no side clearance at all; but, with the usual materials finished by shaving, the wear on the dies is comparatively slight and even with their limited working depth (which is balanced in a large measure by the fact that only a small amount of the surface is removed by each regrinding) they should answer for a large amount of work before requiring replacement.

With shaving dies for german silver, however, it is customary in some shops to make the die straight or parallel all the way through. The shaving of such material imposes severe service upon the cutting edges of the tools and if they were made in accordance with the practice noted above their life would be very materially shortened.

Allowances for Shaving

It is of importance at this point to give a little consideration to the subject of allowances for shaving of blanks. As for any given material, or grade of stock, the condition of the contour of the blank will vary with the thickness of the metal, the amount left for shaving should likewise vary and with a fair degree of uniformity from the thinner gages to the thick material. Similarly the allowance for any given thickness should vary for soft, half-hard, and hard material. In order to cover these allowances for steel blanks of the three grades noted, Table 12 has been developed and has been given thorough tests in connection with numerous shaving dies operating on different classes of work.

This table covers thicknesses of metal from $\frac{3}{64}$ in. to $\frac{1}{8}$ in. inclusive and also includes allowances for german silver and brass. For the latter two materials, it will be noted, the shaving allowances are double those for steel of the same thickness. Table 13 is arranged to give allowances where two shaving cuts are taken. From the quantities under the heading "Allowances for second shave" it will be seen that the amount left for the second shaving operation is one-half that for the first. Thus in the case of a soft steel blank $\frac{1}{16}$-in. thick requiring two shaving cuts, 0.003 in. would be allowed on a side for the first shaving die to remove and 0.0015 in. for the second shaving operation, or a total of 0.0045 in. on a side or 0.009 in. over all, the blanking dies being made 0.009 in. larger than the finished size of the piece.

Referring back to the dies in Figs. 165 and 166, for the gear wheel of 0.050 in half hard steel, the first shaving die would be made to remove 0.003 in. on a side and the second shaving die to finish the piece by removing 0.0015 in. from each side. The blanking tools then must be made larger in diameter than the finish gear dimensions by twice the sum of these two allowances or 0.009 in.

Nests for the Work

The form of nest or locating device on shaving dies varies with the form and size of the work but there are certain conditions to be observed in common in practically all cases. Thus as much clearance as feasible should be provided at the under side of the nest to allow for the ready blowing out of all chips produced in the shaving process; the top face of the nest should be beveled out or chamfered around the contour of the opening to provide

an easy locating medium for the work; the nest opening itself should be just enough larger than the blanked piece to admit the latter readily but without permitting it side play. It should ordinarily be the size of the blanking punch and it may therefore be finished by using the blanking punch for a final broaching tool in working the nest opening to diameter. Under this condition ample clearance will be formed in the nest opening for the shaving punch as the latter is a close fit to the shaving die and is therefore at least several thousandths under the diameter of the nest itself.

As to the chip clearance at the underside of the nest this may well be equal to about two-thirds the thickness of the blanks. A good standard for the nest thickness for the general run of shaving dies is $\frac{1}{4}$ in. as indicated in the sketch in Fig. 166 and with the above ratio of clearance space underside the gap cut out for a blank 0.050-in. thick will be 0.033 in. as given on the detail.

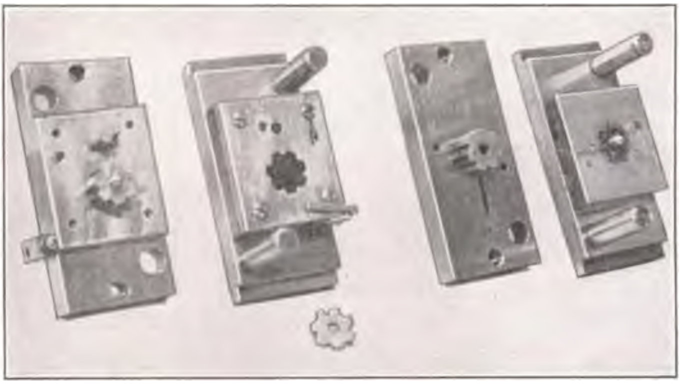


Fig. 167. — Progressive piercing and blanking tools and a pair of shaving dies

The shape of the outside of the nest is best developed toward an approximation of the contour of the blank to facilitate the maintenance of a perfectly clean surface under the nest itself and across the face of the die. This applies more particularly where the shaving die is of the pattern illustrated in Fig. 166 with opening clear down to allow the work as shaved to pass down through the die and shoe.

Other Designs of Shaving Tools

While the foregoing method of shaving blanks by pressing them down through the die one after another, is presumably the most commonly employed, there are numerous instances where such dies are designed for ejecting the shaved blank from the top of the die. Also, the tools are occasionally arranged to operate in inverted order with the die at the top and the punch below. Then again, while the conventional nest is one that

locates the blank on the die by means of its external edge or contour, examples are frequently found where an opening at the center or in some other portion of the blank allows an internal nest or pilot to be employed to advantage, particularly where it is desired to shave the edge in accurate relationship to a pierced hole of this character. An illustration of this arrangement is presented in Fig. 167.

A Piloted Shaving Die

Referring to this view, a set of progressive piercing and blanking tools will be seen to the left, while at the right-hand side is shown the shaving punch and die. The blank produced with the progressive dies is sketched in Fig. 168 and will be seen to be a steel disk $1\frac{1}{2}$-in. diameter by $\frac{1}{8}$-in. thick, with six 90-degree notches in the edge and a central hole measuring 0.4937-in. diameter. One-half inch from the center there is a $\frac{1}{8}$-in. hole which is pierced at the same time as the central opening.

For the shaving operation that follows, a die is used which is fitted with a spring knock-out or ejector in the top of which a $\frac{7}{16}$-in. locating pilot or nest pin is secured while a $\frac{1}{8}$-in. pin is placed at a distance of $\frac{1}{2}$ in. to correspond with the smaller of the pierced holes in the blank. The two pilots thus serve as a means for locating the blanks for the shaving process.

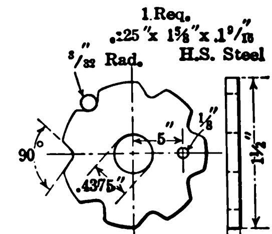


Fig. 168
A Blank Requiring Chains

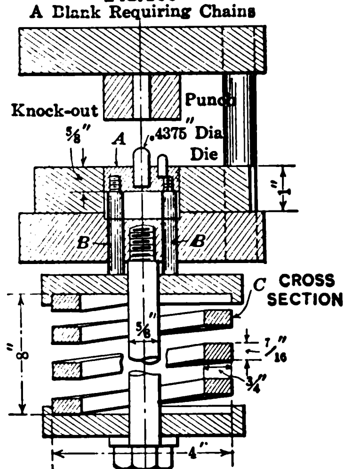


Fig. 169

Figs. 168–169. — Sectional view of shaving dies

The construction of the die is brought out by the sectional view, Fig. 169, which is included here to represent the method of removing the shaved piece from the die opening. The knock-out *A* is $\frac{5}{8}$-in. thick and has a possible movement down into the die opening of $\frac{3}{8}$ in. It is provided with a series of pins *B* which are acted upon by the heavy pressure spring *C* to lift the knock-out and eject the shaved blank. The spring is confined between two disks and the central stud tapped into the bottom of the die shoe secures the attachment in place. It may be readily transferred to any other die requiring similar knock-out apparatus.

As stated the knock-out disk *A* carries the central locating pilot for receiving the work and also has a second pin for entering the $\frac{1}{8}$-in. hole in the blank. The punch is provided with a central hole for the top of the

pilot pin. The disk finished with these tools is part of the mechanism of a coin register. Another piece for the same machine is shaved with the tools illustrated in Fig. 170.

Inverted Shaving Dies

These tools are of the inverted type and the blank is located by placing it over a nicely fitted pilot which, in this construction, is inserted in the punch, the latter forming the lower member of the set of tools. The shaving tools are at the left in Fig. 170 while at the right in the same view are a set of progressive blanking and piercing dies for piercing the central hole and producing the blank ready for shaving. The piece itself is shown with principal dimensions in Fig. 171.

It is a gear wheel of steel, $\frac{1}{8}$-in. thick, 1.875 in. outside diameter, with 28 teeth which must be accurately finished on their contours and concen

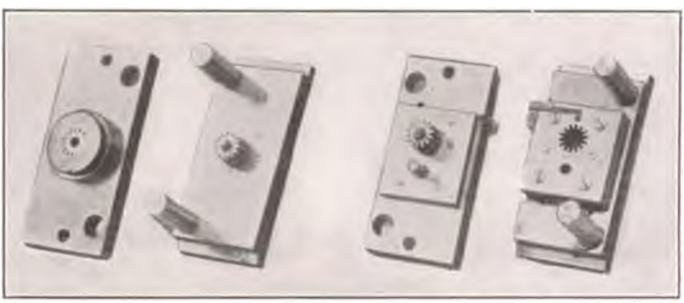


Fig. 170. — Dies for making a gear wheel

tric with the 0.406 in hole at the center. The shaving die, which is adapted to be attached to the ram of the press instead of to the bolster, and thus used bottom side up, as shown by Fig. 172, is made up in the same manner as if constituting the usual lower member of the set. It is finished internally to the size for shaving for a depth of $\frac{3}{4}$ in. and is cleared beyond that point.

In use, the work is located on the punch face by means of the pilot and the die upon descending with the press slide accomplishes the shaving operation and rises with the blank inside. The clamp on the front of the slide for holding punch shanks is removed from the slide to leave a liberal opening over the top of the die shoe and as the shaved blanks pass one by one up through the die they are swept out of the slide opening by the operator. With both of the shaving dies in Figs. 167 and 170, the seat for the blank is readily kept free of chips and dirt and there is no trouble in nesting the work properly.

Comparative Advantages

The two types of dies, as best seen in the sectional views, Figs. 169 and 172, have their advantages for certain classes of blanks requiring shaving, not the least of which is the feature just referred to, the convenience with which the die face is kept clean. The dies in Fig. 169 are used in this particular instance for a thick blank; with thinner work the advantages of the knock-out are more apparent, for the disk *A* then serves as a holder to confine the blank between its face and the end of the punch and by supporting the work fully during the shaving operation it assures its being ejected from the die in a perfectly flat condition.

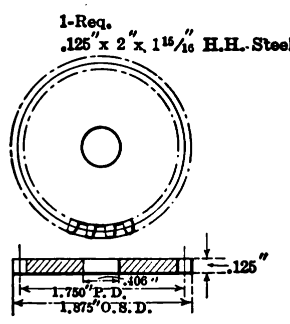


Fig. 171

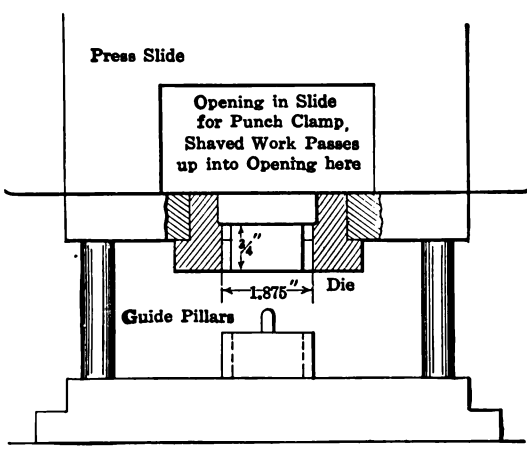


Fig. 172

Figs. 171–172. — Method of resting the work on a pilot with inverted die

The knock-out also prevents possibility of thin shaved blanks stacking up or wedging tightly in the die with likelihood of injury to themselves and the tools. This possible source of trouble with such work is guarded against in a measure in the usual type of die with opening clear through, by confining the sizing part of the die to a limited depth of $\frac{3}{16}$ to $\frac{5}{16}$ in. as already pointed out in this chapter. The clearance below then allows the work to pass out freely at the bottom. This occasional tendency upon the part of shaved blanks to stack up in the die is quite similar to the action of slugs from a piercing punch which with an improperly cleared die will tend to swage against each other and the sides of the die opening and cause trouble of a more or less serious nature.

With the inverted type of die in Fig. 172 the chips or shavings re-

moved from the edge of the blank at each down stroke of the press are carried down over the edge of the punch from which they are readily cleared.

Tools for a Toothed Cam Member

The shaving of an unusual form of blank, requiring the accurate finishing of two or three different surfaces, external and internal, involves at

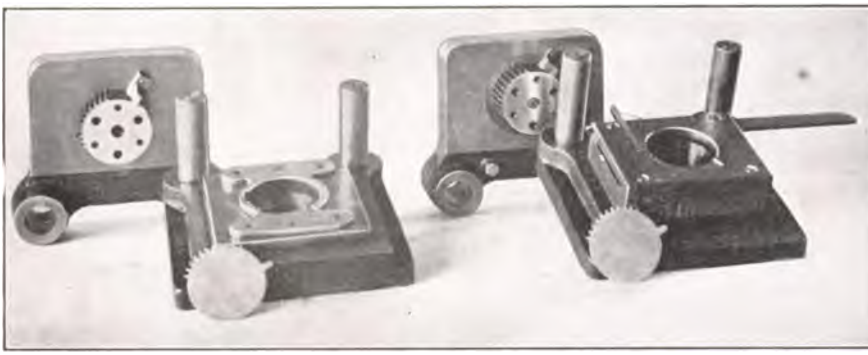


Fig. 173. — Blanking die and a shaving die for outside of work

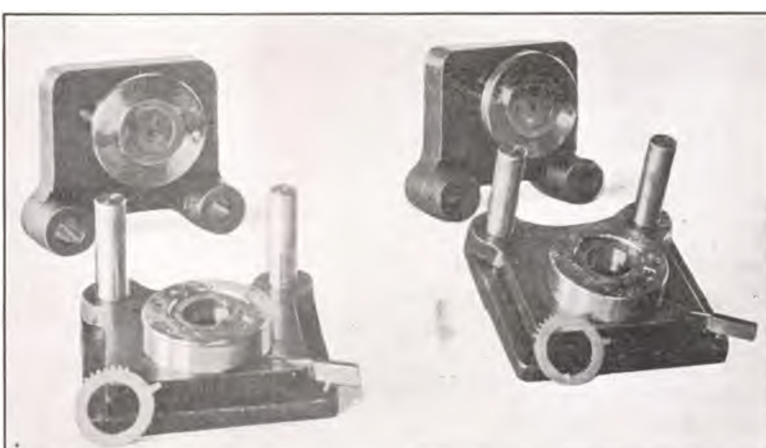


Fig. 174. — Dies for piercing and shaving center hole and notched teeth

times the application of several distinctive shaving operations in as many separate dies. It is a problem of this character that is taken care of by means of the tools in the views that immediately follow:

The three photographs, Figs. 173, 174, and 175, represent three sets of tools, each made up of two pairs of dies for blanking, piercing, and shaving the piece shown by Fig. 176 which is one of nine similar members used in a

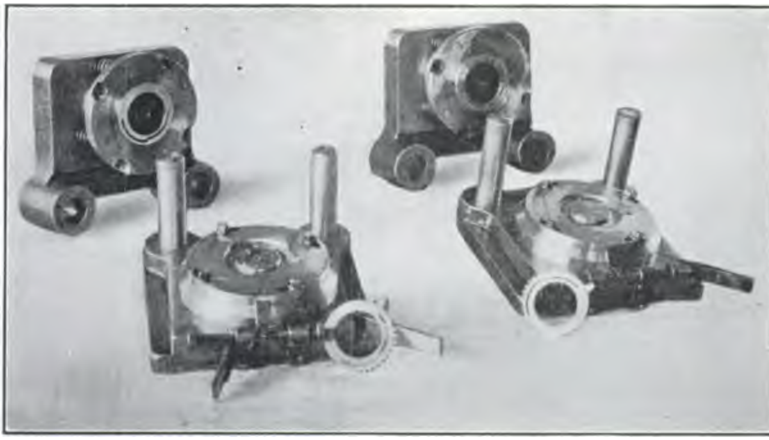


FIG. 175. — Dies for piercing and shaving a cam slot

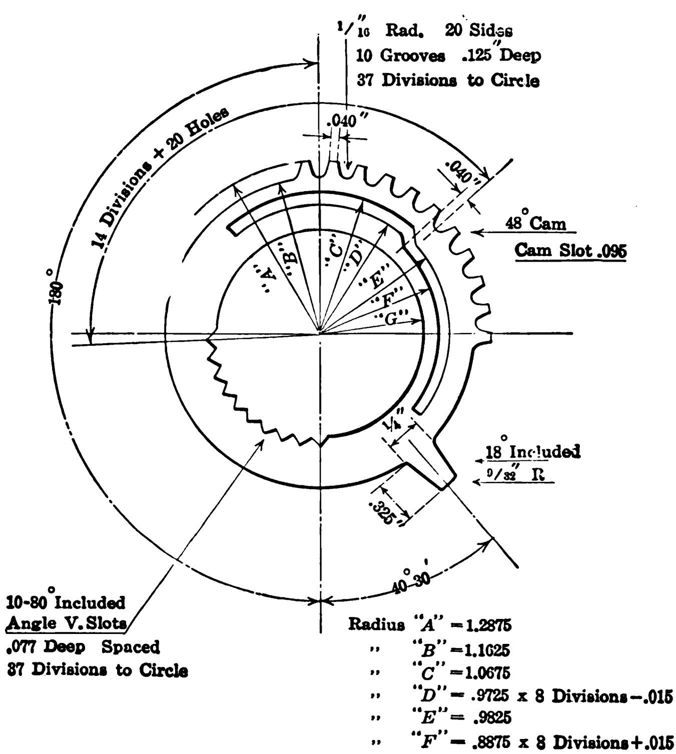


FIG. 176. — The work produced in the tools in Figs. 173–174–175

calculating machine and constituting as a group what is known as a setting drum.

The nine drum disks are all made to the dimensions given for outer diameter, diameter of center hole, size of teeth inside and out, and length and width of the cam slot. The angular relation, however, of the latter slot in respect to the groups of teeth and the projecting lug at one side, varies throughout the set of disks; for the cam slot in each is utilized to operate an individual controlling key which is adjusted radially through the necessary distance by the cam slot which acts upon the head of the key. The position of the rise in the cam slot is therefore of importance and its variation around the disk as a whole throughout the series of nine disks has led to the design of a group of press tools of unusual interest.

General Principles

The disks are of german silver 0.050-in. thick and they are blanked from stock $2\frac{5}{8}$ in. wide. The blanks for the series are all alike externally and so one set of blanking tools answers for all of them.

This blanking operation is followed by an external shaving cut which finishes the outside contour completely. Then the shaved blanks are passed through a set of piercing dies which form the hole at the center and the internal teeth. This operation is followed by the shaving of the center opening and the inner teeth, and then the cam slot is pierced and in another set of dies the slot is shaved.

Up to the point where the slot is to be pierced the disks are all uniform, involving no complications in the construction of the dies. But, for the operations in connection with the slots, special forms of nesting devices are required in order to give each slot the exact individual position necessary for that particular number of disk. That is, there are nine distinct positions for the slots in the different disks and this variation is secured by an adjustable nest which enables one set of dies to pierce all slots correctly and another set to shave them accurately, thus avoiding the necessity of nine separate sets of dies each for piercing and shaving.

Blanking and Center Piercing

The blanking dies for the disk are shown to the right in Fig. 173 and require no special description as they are similar in general design to various other tools already shown in detail in other chapters in this book. It will be noticed that the trigger form of stop is used for the stock and the dies are so laid out as to bring the projecting lug of the blank at an angle of about 30 degrees with the cross center line to permit of the use of a minimum width of stock. The punch resembles one for an interrupted tooth wheel and the portion for blanking out the lug is dovetailed into the edge of the body of the punch. Three fillister head screws and three

dowels locate and secure the punch to its holder or head, which, as will be seen, forms with the die base a set of subpressed or pillar dies.

The shaving tools at the left in Fig. 173 are provided with a locating nest shaped along similar lines to the one described in connection with Fig. 166, although the proportions are somewhat different to correspond with the larger size of the blank to be shaved. The stock being 0.050 in. thick, the amount removed on a side by the shaving die is 0.005 in. as indicated by the value for that thickness under the column for german silver in Table 12.

The dies at the right in Fig. 174 pierce the center opening and form the internal teeth and the tools at the left in the same view accomplish the internal shaving operation required for finishing the inside contour. The nesting of the blank is accomplished in the same manner for both sets of dies and the sketch, Fig. 177, will give a good idea of the general arrangement of the various parts of the tools. While the latter view is more specifically related to the shaving dies it represents as well the essential features of the dies for the piercing operation.

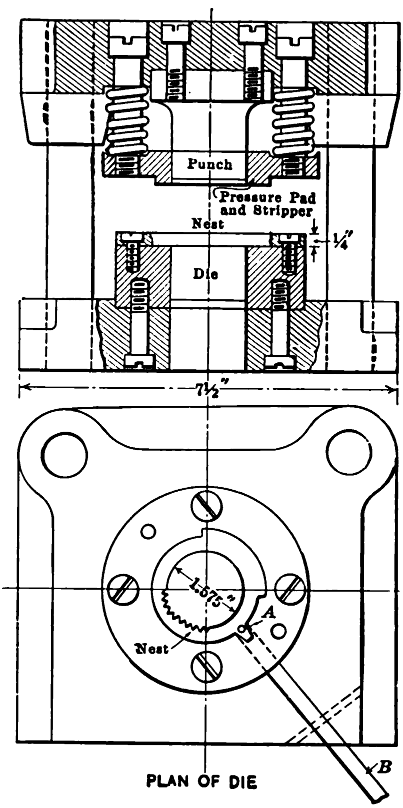


Fig. 177. — Arrangement of "nest" on shaving die

The form of the nest is a close outline of the blank and its depth of $\frac{1}{4}$ in. is relieved around the opening by a liberal chamfer which removes the corner for one-half the thickness of the nest. The punch is provided with a combined pressure plate and stripper which serves to hold the work flat during the operation of the punch and which strips the punch upon the upstroke of the slide. Both dies for the piercing and shaving cuts are provided with ejectors in the form of vertical pins A which are located under the blank and which are operated by downward pressure upon the end of the handle B.

Piercing and Shaving the Cam Slot

Proceeding now to Fig. 175, we find here some most interesting features in die construction. These tools pierce and shave the cam-shaped opening

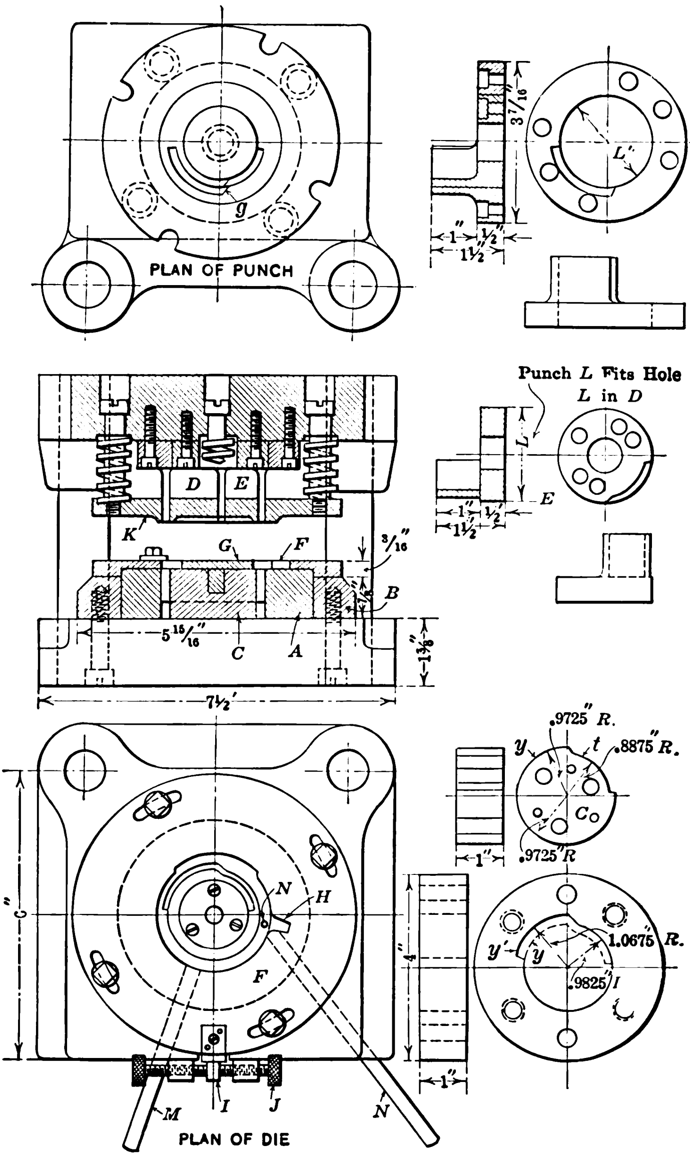


FIG. 178. — Details of slot shaving die

and as they are alike in the main the description may well be confined to the shaving die details which are clearly brought out by the drawing, Fig. 178, and by the photographic groups, Figs. 179 and 180, which show the principal die parts as they appear when the tools are taken apart.

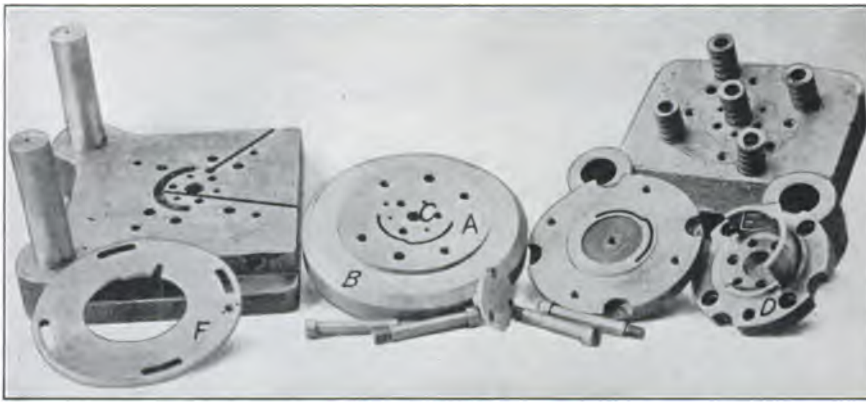


FIG. 179. — Slot shaving dies taken apart

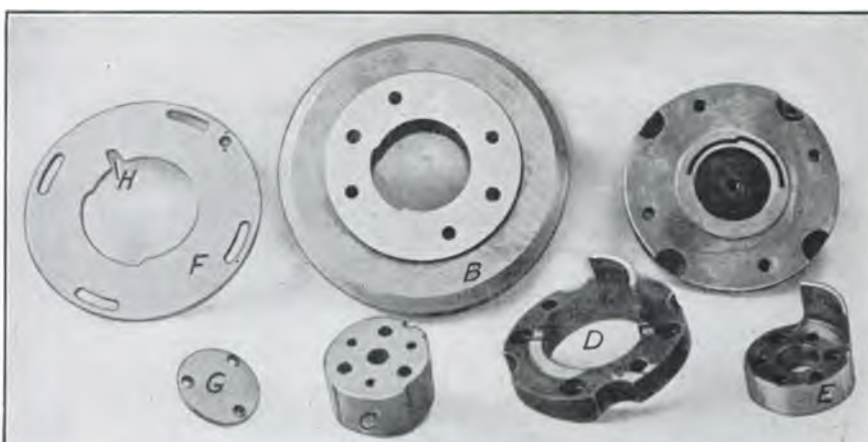


FIG. 180. — Details of slot shaving dies

These dies, as pointed out, cover in the one set the positioning of the nine differently located slots in the disks. They are of sectional construction with punch and die proper each made up of two parts ground to correct relationship to one another.

Referring now to Figs. 178, 179, and 180, where the same reference letters are used for the three engravings, *A* is the main portion of the die which is pressed into a steel ring *B* by which it is secured to the die shoe. This die

A is finished out to a radius of 0.9825 in. except for the portion for the high part of the cam slot which is cut out to a radius of 1.0675 in. The greater part of the bore may therefore be finished by grinding to a diameter equal to twice radius 0.9875 or 1.9750 in.

The smaller section of the die proper shown at *C* is ground for the greater part of its circumference to a diameter corresponding to the interior of the main die *A* and made to fit closely therein. A part of the circumference of *C* is, however, reduced to a radius of 0.8875 in. for the low portion of the cam slot, this being shown at x; and at y another portion of the outside surface is reduced to a radius of 0.9725 in. to give the proper width of gap between that portion and the corresponding edge y' of the main die *A*. These figures may be checked up with the radii given on the drawing of the work in Fig. 176 and will give a clear idea of the manner in which the proper width of slot is provided for between the opposing faces of the two die members described. The position of the holes for the screws and dowel pins for securing the die parts to the base or shoe will be seen in the drawing, Fig. 178, and also in the group photographs.

The Punch Parts

Similarly, the punch proper is constructed with two parts, outer and inner, which facilitate the making of these members. The larger punch part *D* is made with a piercing projection of long enough arc to cover the high portion of the cam slot while the inner member *E* is constructed to pierce the low portion of the slot.

The base of the punch *E* is finished to fit closely in the opening through the bottom of punch *D* and the two members when put together over-lap at the cutting ends as at z to give a smooth continuous cut through the slot at the point where high and low cam slots meet and the edges of both punch parts are beveled at the necessary angle at z to give the correct slope to the cam slot rise. The cutting portions of both punch members are ground after hardening to give the required inside and outside radii.

The Adjustable Nest

The work to be shaved is placed in the adjustable nest *F*, where it fits with its shaved center located over the thin pilot disk *G*, and with its projecting lug in the notch in the nest at *H*. The latter gives all the pieces to be shaved a definite position in the nest and it remains only to adjust the nest upon the die to secure any desired location around the circle for the cam slots. This adjustment is secured as follows: The nest is seated by a recess in its underside which fits over the top of the die ring *A*. It is adapted to be clamped in position by the four screws passed through the curved slots near the edge. At the front is secured a short arm *I* which is engaged by the opposing thumb screws *J* for adjustment either to right or

left. Thus while the punch and die remain in fixed position, the nest and work may be set around to a master for the locating of the slot according to the requirements for that particular job. After one lot have been run through the dies, the nest is reset for the next number in the series of cam disks and so on with the entire lot.

The punch holder is fitted with a spring actuated pressure pad and stripper *K* which is backed by five springs, one of which is located at the center where it passes up through the sectional punch into contact with the back of the stripper. There is a knock-out in the die slot, actuated by the handle *M*, for ejecting chips and a pin knock-out at *N* operated by handle *O* for lifting the finished work from the die.

Between the piercing tools and the shaving dies made to the same general design as the ones just described, there exists but few points of

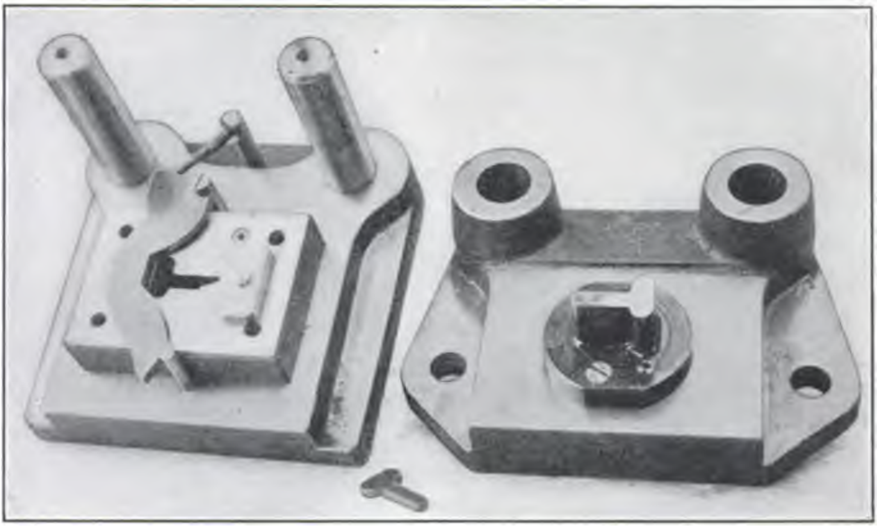


Fig. 181. — Shaving dies with open nest

difference. The piercing dies are enough smaller than the shaving tools to allow the right amount of material for a satisfactory shaving cut which has been determined to be, for this thickness of work, 0.005 in. on each side.

Special Form of Nest for a Thick Blank

In shaving blanks of unusual thickness the chip removed is likely to prove troublesome if the work is located in the customary form of nest, for it is usually impossible to provide sufficient clearance under the latter to take care of the relatively thick, deep shaving removed from the contour of the blank. In such instances an open nest may be employed along the lines of the one used on the die in Figs. 181 and 182.

The shaving tools here represented operate on a half hard steel blank $\frac{9}{64}$-inch thick although the piece itself is only $1\frac{5}{16}$ in. long over all. The amount shaved from each side is about 0.010 in. and an enveloping nest would consequently be impracticable for the reason noted above. So the

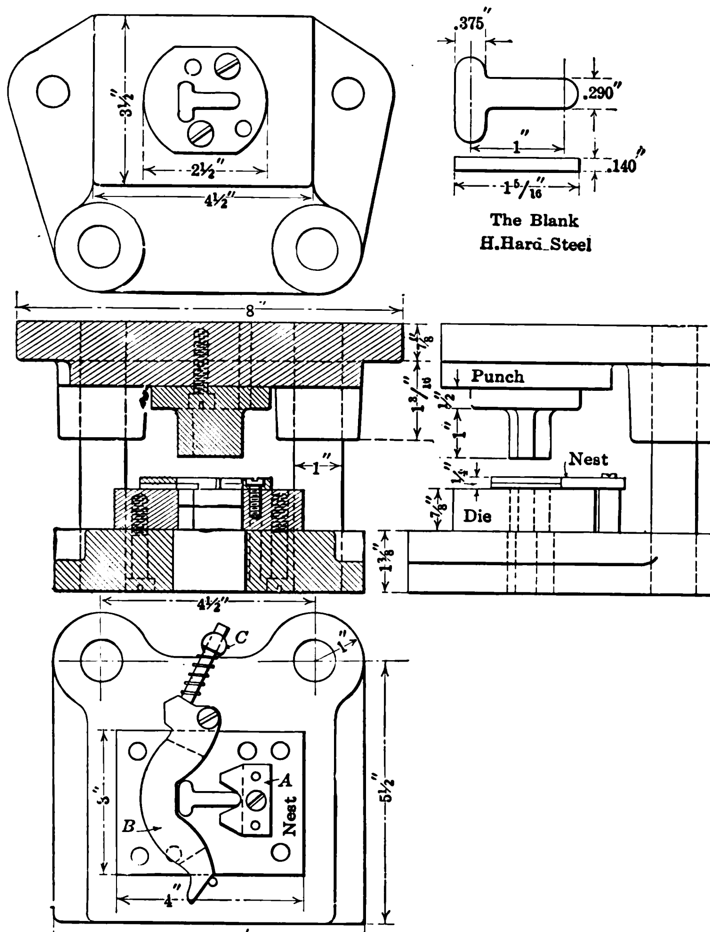


Fig. 182. — Construction of dies with special form of nest

nest was constructed as shown, with a fixed V for locating one end and a swinging latch at the opposite end which is actuated by a spring to force the blank into central position over the die opening.

The two nest elements are shown at *A* and *B*, Fig. 182, the former with its narrow V notch for receiving the round end of the blank, the latter with a wider V for centering the broad end of the work. The spring for controlling the swinging member *B* is compressed between the heel at the rear

of the pivot and a drilled post *C* secured at the back of the die base. Both parts *A* and *B* are cut away underside for chip clearance, as indicated by the dotted lines in the plan view in Fig. 182. The edge formed by this clearance cut acts as a stripper for the punch. The swinging arm or gate *B* allows the operator to keep the face of the die free from chips and to place successive blanks in position with ease and rapidity.

Other Forms of Dies

It will be noticed that all of the examples of shaving dies illustrated in this chapter are provided with guide pins or pillars to assure correct alinement of punch and die, which is an essential feature with such tools. This form of construction is in fact coming into general use in progressive shops for a large share of the press work handled in other classes of dies as well as in shaving tools.

The shaving dies in the preceding pages have all been shown as used for direct finishing of parts produced in some form of blanking die. There are, however, in different press rooms numerous cases where shaving tools are employed for operations on blanks that are passed through trimming dies before shaving, or produced at the outset in trimming dies without preliminary blanking. Then, again, there are various interesting examples of shaving dies combined in one set with trimming tools so that the two distinct operations are performed in progressive fashion.

In the chapter that follows a number of trimming dies are illustrated and in conjunction with them several further types of shaving tools are shown.

Table 12. — Amount to Allow on a Side for Shaving Contour where Only One Shave is Taken

Thickness of blank	Soft steel	Half-hard steel	Hard steel	German silver	Brass	Thickness of blank
Inch	Inch	Inch	Inch	Inch	Inch	Inch
$\frac{3}{64}$ (0.0468)	0.0025	0.003	0.004	0.005	0.005	$\frac{3}{64}$ (0.0468)
$\frac{1}{16}$ (0.0625)	0.003	0.004	0.005	0.006	0.006	$\frac{1}{16}$ (0.0625)
$\frac{5}{64}$ (0.078)	0.0035	0.005	0.006–0.007	0.007	0.007	$\frac{5}{64}$ (0.078)
$\frac{3}{32}$ (0.0938)	0.004	0.006	0.007–0.008	0.008	0.008	$\frac{3}{32}$ (0.0938)
$\frac{7}{64}$ (0.1094)	0.005	0.007	0.009–0.011	0.010	0.010	$\frac{7}{64}$ (0.1094)
$\frac{1}{8}$ (0.125)	0.007	0.009	0.012–0.014	0.014	0.014	$\frac{1}{8}$ (0.125)

TABLE 13. — AMOUNT TO ALLOW ON A SIDE FOR SHAVING CONTOUR WHERE A SECOND SHAVING OPERATION IS USED

Thickness of blank	Allowance for first shave			Allowance for second shave			Thickness of blank
	Soft steel	Half hard steel	Hard steel	Soft steel	Half hard steel	Hard steel	
Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch
$\frac{3}{64}$ (0.0468)	0.0025	0.003	0.004	0.00125	0.0015	0.002	$\frac{3}{64}$ (0.0468)
$\frac{1}{16}$ (0.0625)	0.003	0.004	0.005	0.0015	0.002	0.0025	$\frac{1}{16}$ (0.0625
$\frac{5}{64}$ (0.078)	0.0035	0.005	0.006–0.007	0.00175	0.0025	0.003 –0.0035	$\frac{5}{64}$ (0.78)
$\frac{3}{32}$ (0.0938)	0.004	0.006	0.007–0.008	0.002	0.003	0.0035–0.004	$\frac{3}{32}$ (0.0938)
$\frac{7}{64}$ (0.1094)	0.005	0.007	0.009–0.011	0.0025	0.0035	0.0045–0.0055	$\frac{7}{64}$ (0 1094)
$\frac{1}{8}$ (0.125)	0.007	0.009	0.012–0.014	0.0035	0.0045	0.006 –0.007	$\frac{1}{8}$ (0.125)

CHAPTER VII

TRIMMING DIES—TRIMMING AND SHAVING

There are two general classes of trimming dies. One class includes those which are used for removing the burr and superfluous metal from such articles as drawn shells, utensils of one kind or another, and other cylindrical and square containers, boxes and the like where extra metal which must be allowed in the blank for the processes of drawing and forming has to be removed in the form of a rim during or following the drawing or forming operations, according to whether the work is performed with simple, progressive, or combination dies.

The other class of trimming dies is employed for operating upon the contour of a blank or upon some portion of an article of either regular or irregular form which may require the cutting out of a notch or other opening along the edge, or the finishing of one or more sides or edges by cutting out some part of the metal at the necessary points.

The first class of trimming dies referred to above is the more commonly used but as they are closely identified with the operations of drawing and forming which have not as yet been described in detail in this book, they will be considered later. The present chapter will be confined to trimming dies of the character noted in the preceding paragraph.

General Advantages

These trimming dies, while of wide importance in the press shop, are not employed to anything like the degree that they should be, and in this respect their status is something like that of the shaving tools to which a chapter has already been devoted. Oftentimes their work is quite similar to the operations performed with shaving dies although as a rule they differ from the latter in that they usually modify the shape of the work materially, or if made to follow closely some portion of the contour they are generally designed to remove a much greater amount of metal than is the practice with shaving dies, which, as already explained, are intended for taking a cut of a few thousandths of an inch only, at the most. Occasionally, shaving dies are used to finish some part of an object already brought closely to size by trimming; and the operations of trimming and shaving are sometimes combined in progressive types of tools for making a piece complete from a strip of stock, which is first operated upon by the trimming

dies to give the required outline at the edge, then advanced to the second position in the press where the shaving tools finish the trimmed portion, then advanced again for cutting off with a parting tool, after which each stroke of the press slide results in the production of a finished blank.

Trimming dies facilitate the production of many articles that it would be practically impossible to make in blanking tools alone or, if actually admitting of such treatment, would necessitate the employment of unnecessarily expensive and complex dies whose first cost and later upkeep would amount to an undesirable total. Again, where several different parts are to be manufactured to the same form, but of varying width or length, involving ordinarily a set of blanking dies for each length of piece, the adoption of a trimming die makes it possible to blank all of the pieces

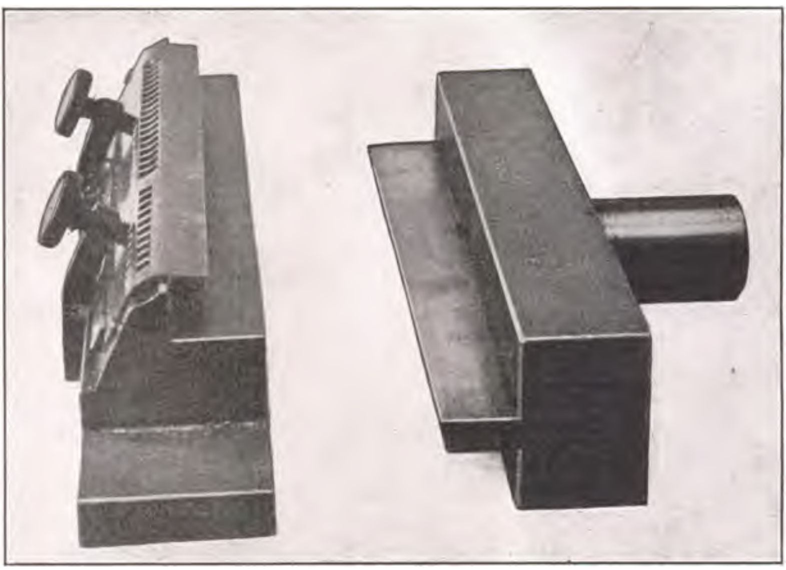


Fig. 183. — Trimming tools

uniformly in a single set of dies and then trim them to their individual lengths, thus eliminating the necessity for more than the one set of first operation tools.

Simple Trimming Dies

In their simplest form trimming dies resemble in construction and operation, an ordinary shearing or cutting-off die; but usually, even when made for merely cutting straight across the work, they have their own peculiar features, particularly in reference to the means incorporated for locating the piece accurately in respect to other cuts already taken, and for holding the work during the trimming process. The latter feature in fact

occasionally gives the trimming die a closer resemblance in appearance to a special fixture than to a press tool.

The photograph, Fig. 183, illustrates a case in point: This set of tools is for trimming the edge of a machine cover which has been passed through a number of press operations until its completion requires nothing further than the cutting off of the edge to a straight line a certain distance from the

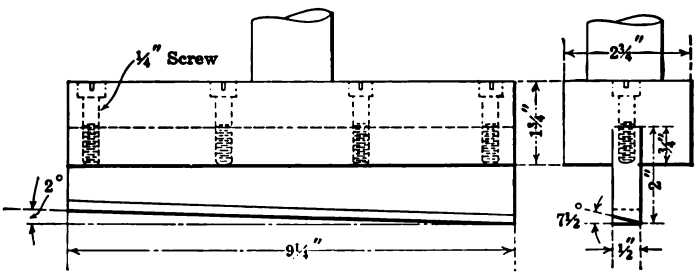


FIG. 184. — Trimming tools

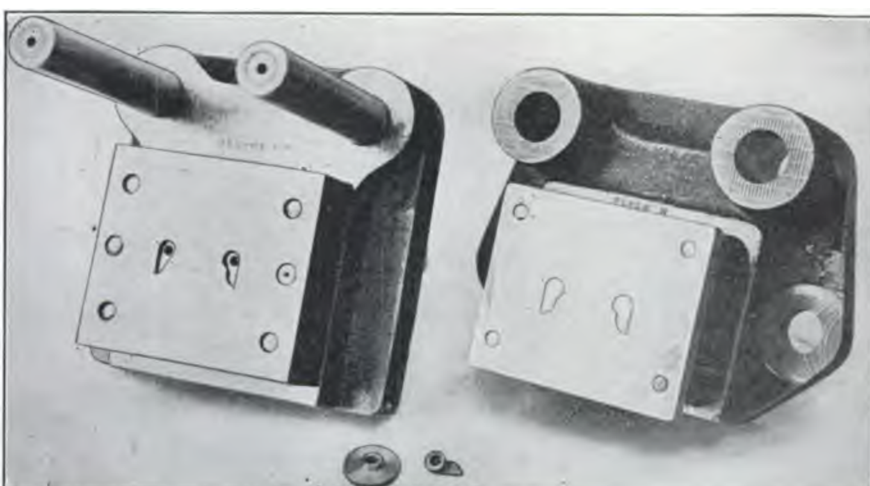


FIG. 185. — Dies for trimming cams from a disk

point where the bent portion meets the straight lip. The work rests on the die upon a stop surface at the left which gives it the desired location in reference to the cutting edge and it is here secured by two knurled head clamp screws while the sheared knife edge forming the punch cuts the metal straight across.

The sketch, Fig. 184, shows the manner in which the edge of the cutting blade is cleared for side shear and also the lengthwise slope which gives the cut a shearing action clear across the work. The side angle is 7½ degrees

and the lengthwise slope has an angle of 2 degrees. The edge of the die or lower member of the set of tools is reduced to a width of about $\frac{1}{16}$ in. as seen in the photograph, to provide a concave clearance for an embossed surface formed along the work under the pierced holes. The cover trimmed with these tools is $9\frac{1}{4}$ in. long and it is made from cold rolled steel 0.040 in. thick.

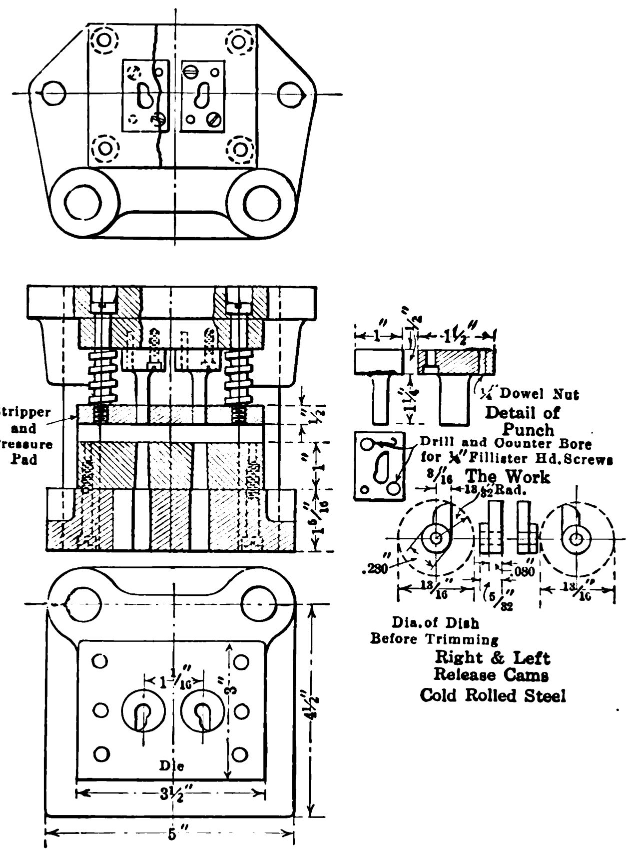


Fig. 186. — Trimming dies for a small cam

A Trimming and Shaving Job

A piece of work involving both trimming and shaving is shown in Figs. 185 and 186. This is a small steel cam with a radius from center to point of $\frac{13}{32}$ in. It is used on a calculating machine, and it forms an unusually interesting application of the trimming principle, for the blank is not made from sheet stock but instead is produced in the screw machine where it is turned out to the form of a disk 0.080-in. thick, with a hub finished to 0.280-in. diameter, and a hole drilled and reamed through the center to

0.155 in. Thus in the shape of a thin disk it is passed through the press tools for the making of the cam contour instead of being finished by the more conventional process of milling to shape.

The cam is made both right and left hand, one each being required for each calculating machine. The dies are correspondingly made for right and left-hand lobes, a duplication of die openings made necessary by the hub extending at one side of the cam. The disks are placed in the dies with the hub located in the round end of the opening and the punch upon descending removes all of the superfluous metal around the cam by forcing the latter into the die. The cam is pressed down into the die by the punch to a sufficient distance to allow the next blank disk to enter hub down, but with the lower face of the disk resting upon the face of the die.

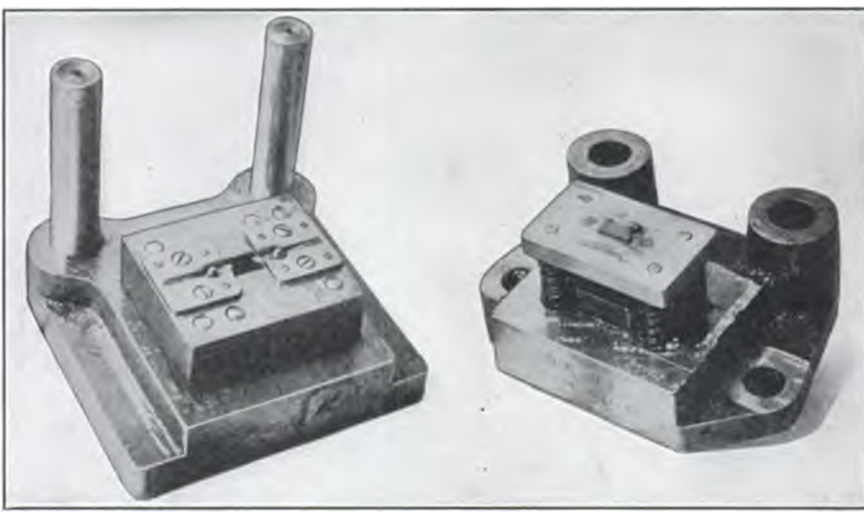


Fig. 187. — Shaving dies for a small cam

The construction of the die is shown clearly in Fig. 186. The die openings are located at a distance of $1\frac{1}{16}$ in. apart to allow two blank disks to clear one another when placed for trimming and to permit of the punches being made separately with ample size of base for stability. The shape of the punches is seen in the detail and it will be noticed that each is made with a base 1 by $1\frac{1}{2}$ in. in area and secured by two $\frac{1}{4}$-in. fillister head screws and two dowel pins of the same diameter.

The pressure pad and stripper carried by the punch head is fitted closely to the punches and is normally held downward upon the work when the slide descends by means of four stiff pressure springs located at the corners on $\frac{5}{16}$-in. screws. The action of the springs and plate upon the upstroke is, of course, to strip from the punches the trimmed-off portion of the disk left in the making of the cam.

Shaving the Cams

These trimming dies leave about 0.003 in. on a side at the point of the cam for finishing in the shaving tools, which are shown by Figs. 187 and 188. The die is made to shave two cam points at once, one right and one left-hand and the work is placed with the two points facing each other, in which position each cam is located with its reamed hole fitting over a pilot

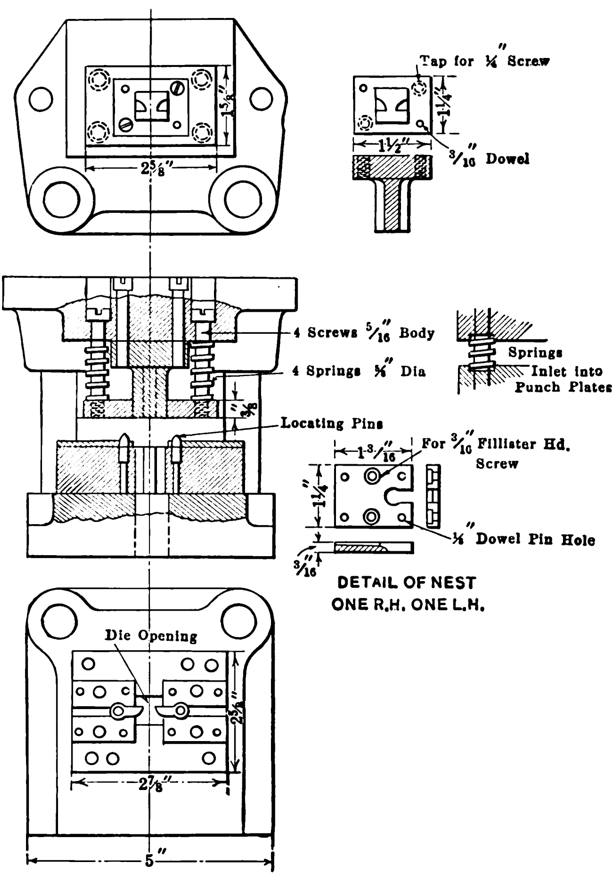


Fig. 188. — Details of cam shaving dies

pin in the die face and with the cam body lying in a slot in the nest plate secured to the die.

The cam points are thus positioned to allow a single punch with shaving edges on opposite sides to finish both cams at once.

Details of punch, die nests, and pilot pins, spring stripper, etc., are all brought out clearly in the drawing, which should require no further description.

Like many of the tools illustrated in previous chapters, the trimming and shaving dies for the cams and those that follow are provided with guide pins or pillars for preserving truth of alinement with consequent accuracy and longevity in operation.

Another Trimming and Shaving Die

The steel piece in the foreground of Fig. 189 is another example of trimming and shaving work, which is shown in detail in Fig. 190. This small lever, which is blanked from half hard steel stock, is 0.140-in. thick and prior to reaching the dies in Figs. 189 and 191 it has been shaved all the way around and pierced in separate press operations. Both shaving

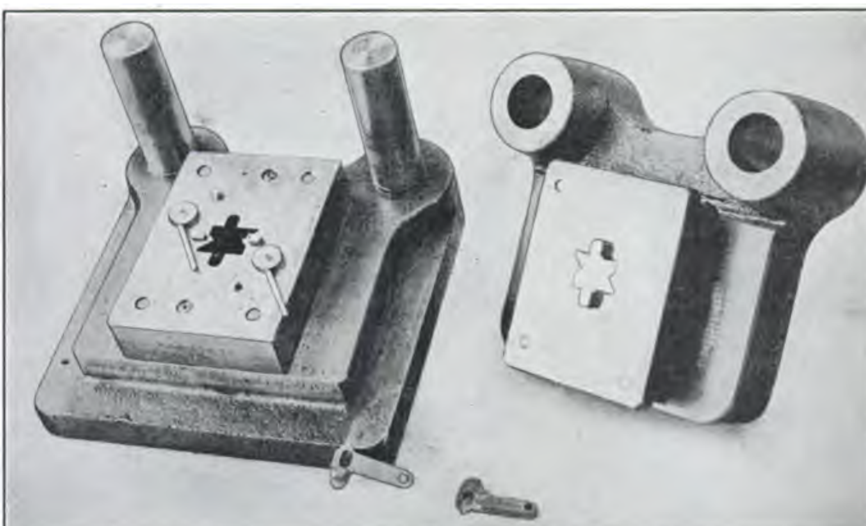


Fig. 189. — Trimming and shaving cams for a small lever

and piercing dies are illustrated at another point in this book. See Figs. 94 and 182. The heel of the lever and the point have been milled down to dimensions given and the object of the operations in the present dies is to trim the round end to an angle at *A* and shave it accurately.

The die is so made that the right-hand side of the opening, Fig. 191, is adapted for trimming the work to form the V point, while the opposite side is for the shaving operation, as indicated in the plan view. The blank, No. 1, at the right is shown as it appears after trimming, and the other piece, No. 2, occupies the shaving position. After the latter is removed the blank at the right side is transferred to the left and a fresh blank placed in position 1 for trimming. Thus at each stroke of the press one piece is trimmed and another shaved. The latter operation removes about 0.010 in. of metal from each side of the angular point.

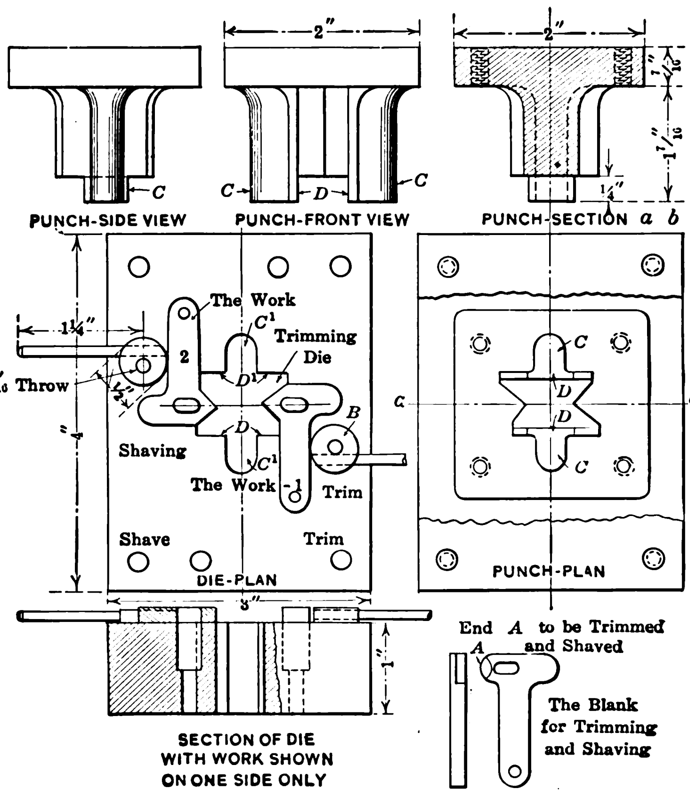
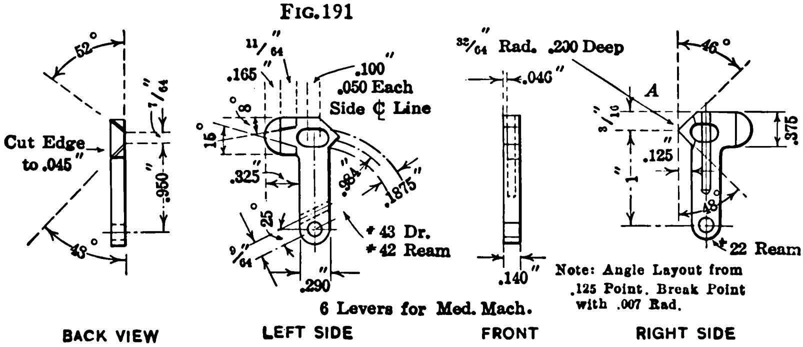


FIG. 191



Transfer Lever. 12 Req. .145 x 2¼"H. Hard Stock.

FIGS. 190–191. — Trimming and shaving tools for a small lever

The method of holding the work at each side of the die is to slip it over two locating pins which fit the small round hole at the end and the oblong opening in the head of the work, and then swing the eccentric binder *B* by the small handle to secure the piece in place.

The punch is illustrated in plan and by several elevations. It has two guiding extensions *CC* which are $\frac{1}{4}$ in. longer than the cutting face and which enter the corresponding guide openings *C'C'* in the die to that depth before the cut is started. The shoulders *DD* fitting between sides *D'D'* in the die still further steady the punch for the trimming and shaving cuts.

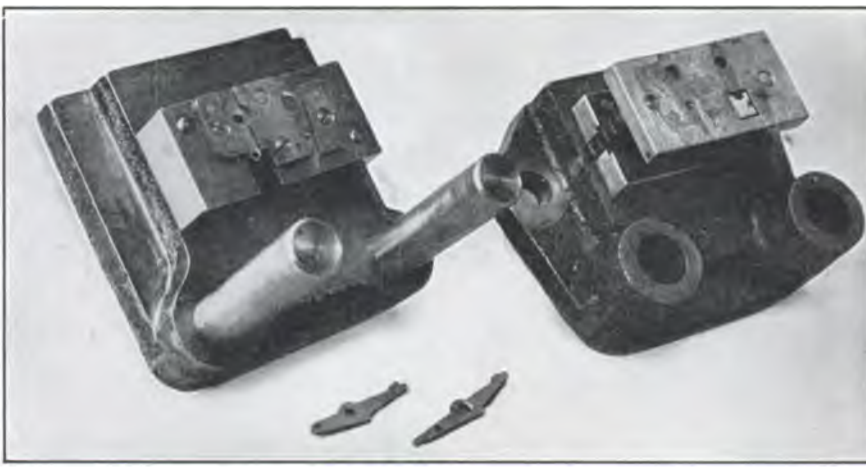


FIG. 192. — A piercing and trimming die

The pressure pad or stripper fitted over the punch is controlled by four springs under the corners as shown clearly by Fig. 189.

DIES FOR PIERCING AND TRIMMING

Another form of shaving die combined with piercing tools is illustrated in Figs. 192 and 193 for operations on the two rocker arms shown in Fig. 194. These two steel pieces are blanked from $\frac{3}{32}$-in. stock and are alike as they come from the blanking dies. The trimming and piercing dies in the above engravings are then used for piercing one-half of the lot of rocker arms as at *X*, Fig. 194, and for trimming off and piercing the other half of the lot to make the shorter piece *Y*.

The drawing of the die and punch plate in plan view shows the method of placing two blanks at once in the nests on the die face, and the notation on the views indicates the operation performed by each punch and die in the set.

Thus the trimming punch *A'* trims off the end of one of the rocker arms at *A*, the portion removed being indicated by dotted lines. The punch *B'*

and die $B2$ pierce the hole B; the punch C' and die $C2$ pierce the larger hole C. The rocker arm X at the left is pierced by punches D' and E' which act with dies $D2$ and $E2$ to form the holes D and E. The end of the work in this side of the die is not trimmed but is left to the blanked size.

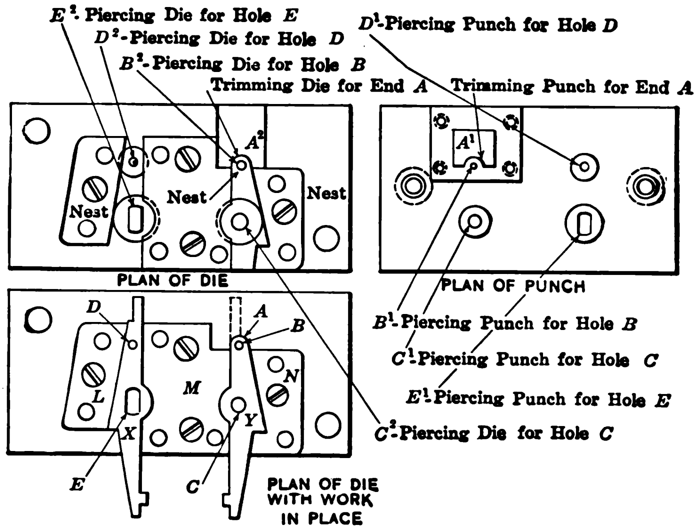


FIG. 193. — Trimming and piercing die

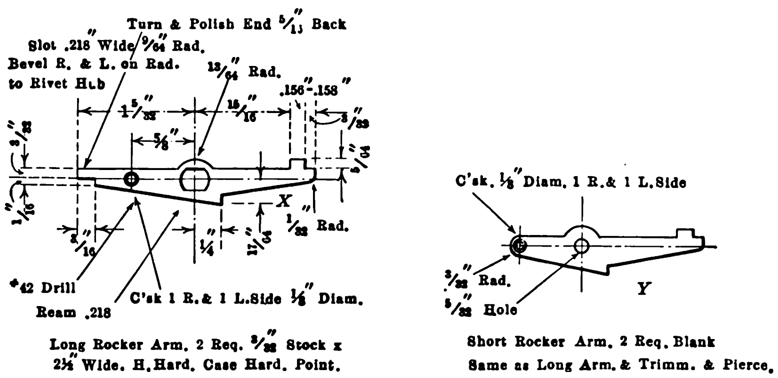


FIG. 194. — Rocker arm detail

The trimming punch A', it will be noticed, enters into and is guided by the slotted opening $A2$ in the rear of the die. It performs its work before the piercing punches enter the blanks. The die hole $B2$ for this end of the short rocker arm is formed in the trimming die itself, as shown by the half-tone, Fig. 192, but the other piercing dies are in the form of bushings which are inserted in the die plate where they are represented by dotted and full line circles.

The nests for the two pieces worked in these dies are made up of three plates *L*, *M*, and *N*, which are secured by screws and dowels to the die face. These nest plates are made to match the straight edges of one side of the work and the tapered edge on the opposite side. The wide center of the work is blanked to a radius of $\frac{13}{64}$ in. and this circular portion fits into a similarly shaped seat in the edges of the middle nest plate *M* to locate the piece endwise.

APPLICATION OF THE "KNOCK-OUT"

Where work of irregular outline and slender proportions is to be trimmed by forcing it down into a die, leaving the trimmed scrap or rim on the die surface, it is advisable to use a knock-out to eject the trimmed piece from

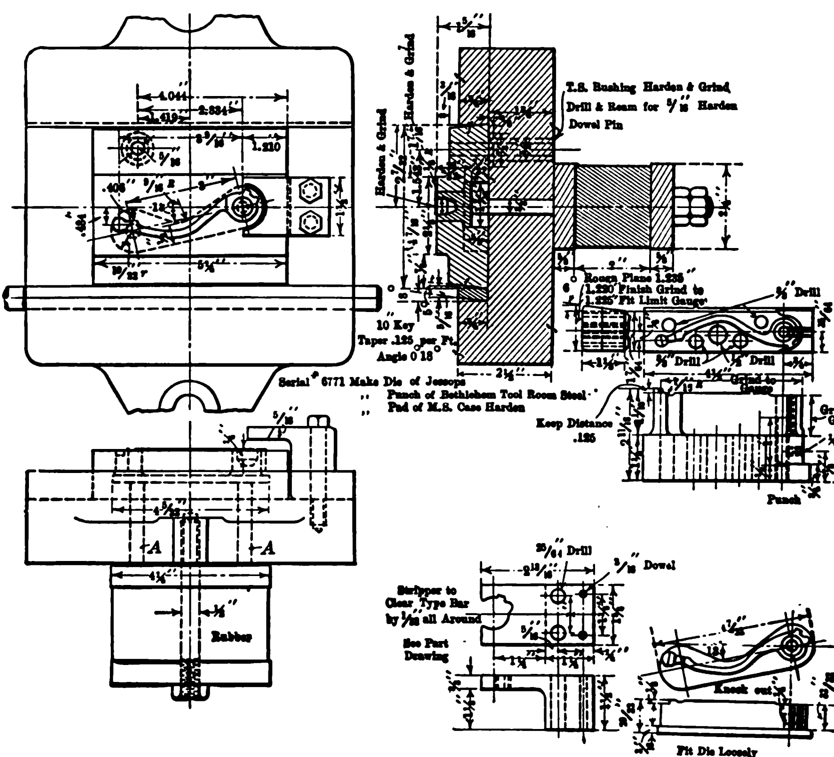


FIG. 195. — Trimming die for a curved part

the top of the die to avoid possibility of the work becoming clogged or stacked in the die and injured by bending.

An illustration of a die of this character is presented in Fig. 195 herewith. It is for trimming a typewriter type bar which has a long, slender, and crooked body well adapted to give trouble in any effort to pass it

through an open trimming die. So the die is made as illustrated with a knock-out which ejects the work after the trimming operation.

The outline and dimensions of the type bar will be seen from the drawing. The arrangement of knock-out and stripper are equally clear, but brief reference may be made to certain features. The knock-out is operated by a rubber spring of liberal proportions under the die base and two pins at *AA* serve to connect the knock-out and spring. The knock-out is made to have $\frac{1}{32}$-in. clearance all the way around in the trimming die and its flanged base fits up into the under side of the die as illustrated by the cross section. The stripper is an open end affair bolted to the right-hand end of the die.

Operations on a Tube

Sometimes dies are required for trimming the ends of round and square tubing where a half round or other shape of opening is wanted, and an example of a piece of work of this character is presented in Fig. 196.

The tube is of brass, 2 in. square, and requires a concave cut to be taken at each side as shown at *C*. This concave portion is formed to a radius of $2\frac{1}{2}$ in. and the depth of cut from the end of the tube is about $\frac{7}{16}$ in.

The trimming die consists of a die proper at *D* set into the shoe *E*, the die being made with a $2\frac{1}{2}$-in. opening to correspond with the diameter of the punch *F*. The block *G* is secured to the die shoe to carry the stripper *H* and is bored out to form a support for backing up the punch which slides closely in the guide bored in *G*. Block *G* is planed out to form a rectangular opening in front for the square tube to enter and when the work is slipped into place it rests with its inner end against the flattened face of the trimming punch at *F*.

The punch is cut back for its entire length except for a portion about $\frac{3}{4}$-in. wide which is left with its original circle as a cutting edge for trimming out the concave end of the work. In operation the tube to be trimmed is placed as indicated with the flattened portion of the punch face for a stop and then the lower side of the tube is trimmed to the desired concave. Then the tube is turned half over and the operation repeated for the second side.

Adjustable Trimming and Shaving Dies

Reference has been made in the foregoing pages to the possibility of using trimming dies for cutting blanks of uniform pattern to different lengths in order to save duplication of blanking dies for each and every different size of piece in the series. An illustration of this principle is contained in the views that follow, which show the method of blanking, trimming, and shaving a set of nine steel cams for a calculating machine, these cams varying in length throughout the group of nine parts. Only one

set of blanking tools is required, and one second operation die accomplishes the trimming and shaving of the entire lot of cams.

Three of the set of nine cams are shown in detail in Fig. 197 and the

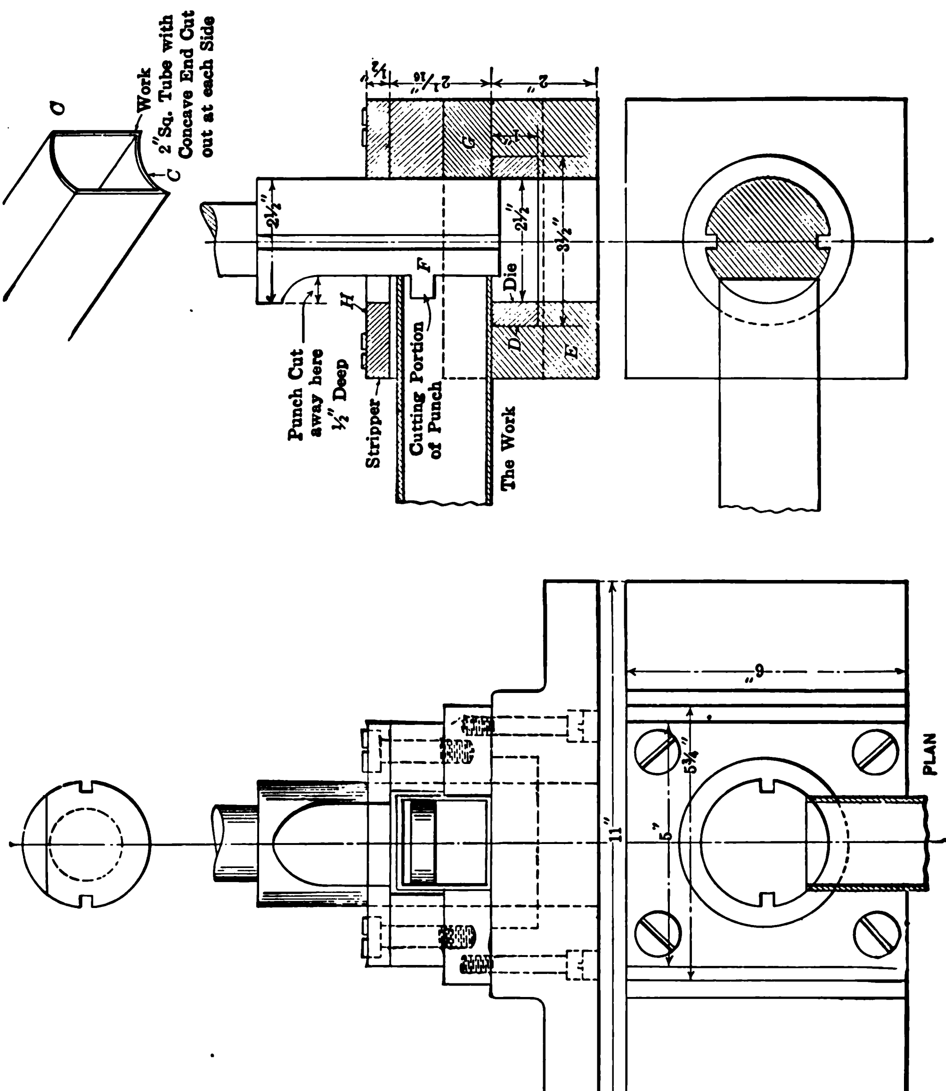
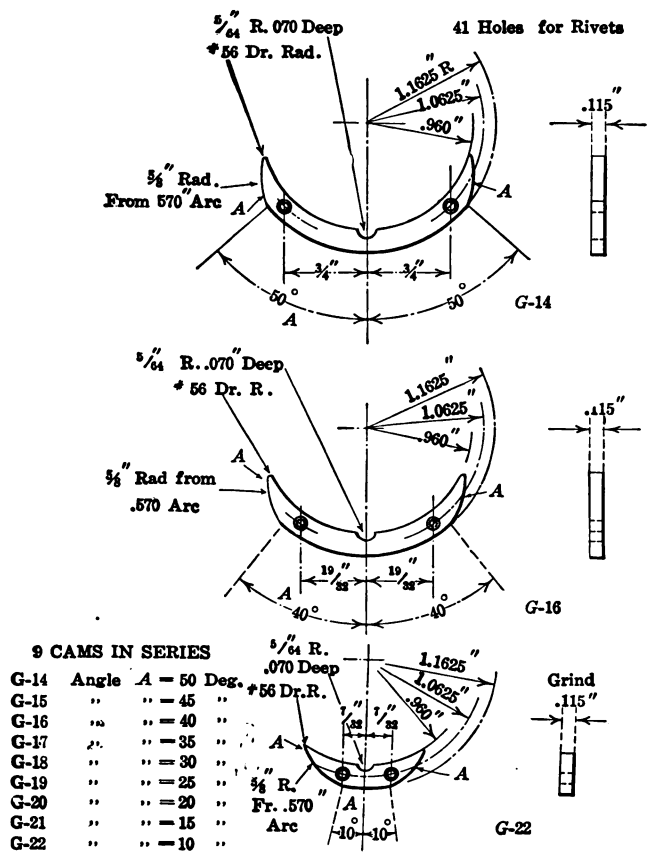


Fig. 196.—Trimming tools for a square tube

table at the side gives the variation of all of the cams in the series as indicated by the number of degrees from the center line to the top of the cam riser near each end. Thus the range for the cams is from 50 degrees down to 10 degrees as measured from center to point of throw. The cam ends

at the arc A are all alike and this arc is struck from a radius of 0.570 in. in all cases. This makes it possible to utilize one trimming die for all sizes of cams, as the portion operated upon in finishing the blank is uniform throughout the series of cams.

The blanking tools are seen in Figs. 198 and 199 and the latter shows the method of locating the stock gage so that it drops into the opening in



STEEL CAMS

Fig. 197. — Details of three cams of a set of nine

the scrap immediately ahead of the blank that is being punched out. The stop is of the trigger type with projecting end for operation by the adjustable striking screw in the punch head when the latter descends. At the right is a spring actuated pressure finger for holding the heavy stock closely to the back guide under the stripper. It will be noted that this stock is 0.120-in. half hard steel.

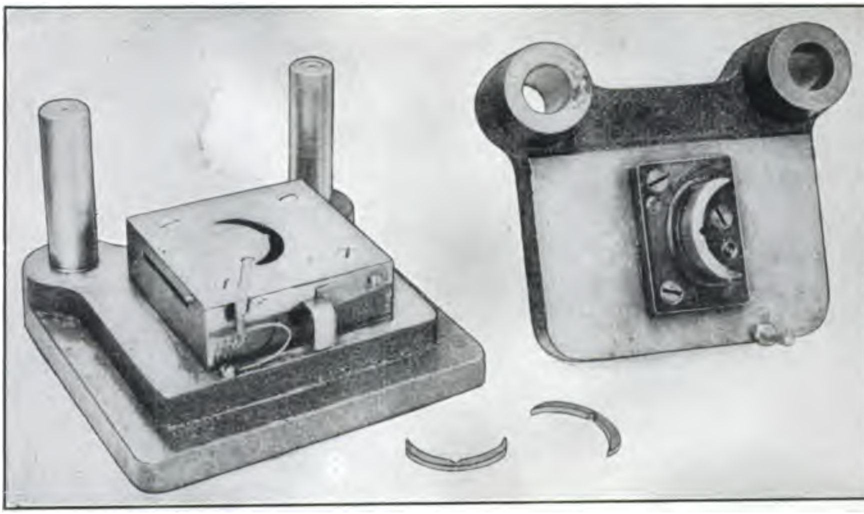


FIG. 198. — Cam blanking dies

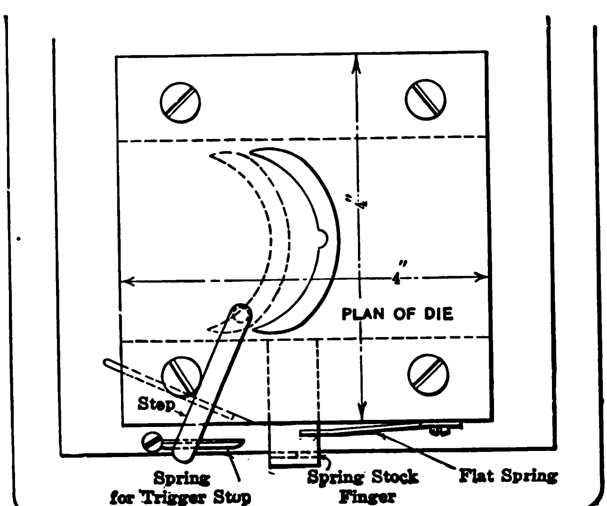


FIG. 199. — Cam blanking die

Construction of Trimming Die

The trimming dies (which are also used for the shaving operation) are shown by Figs. 200 to 205 inclusive. In the first of these views the entire series of nine cams of different lengths are shown in the foreground and the locating nest is seen empty with three knock-out pins projecting slightly above the bottom of the work seat just as they are thrown up by the handle in front when the trimmed cam is ejected. In Fig. 201 the middle length of cam, No. 18, as it is called, is seen in position in the nest which is here shown adjusted around to central position. In the preceding view, Fig. 201, this locating nest is seen at the extreme right-hand position or in the

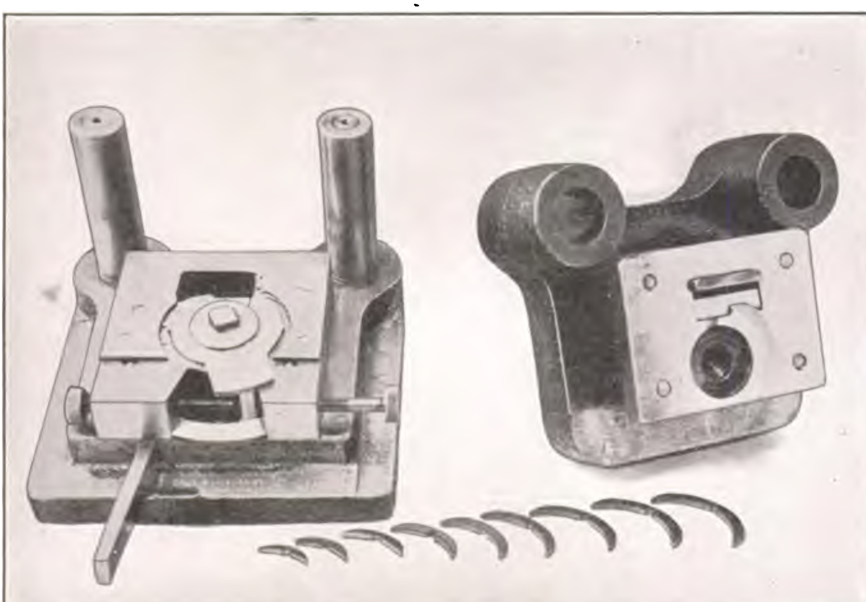


Fig. 200. — Trimming and shaving dies for a steel cam

place in which it is set for the longest cam of the series, namely, No. 14. In Fig. 202 the graduations at the front of the die for giving the nine positions for all of the cams are plainly seen.

It will be gathered from these views that this die is arranged to take the same cut on all of the cams, that is to give the ends of all cams the same form; but each number of cam is cut to a different length from the other cams in the series, so that more metal is trimmed off from some cams than from others, the amount removed varying with each cam member.

Referring now to Fig. 203, this drawing shows at *A* a half round lug on the locating device *B* which is used for positioning all lengths of cams from

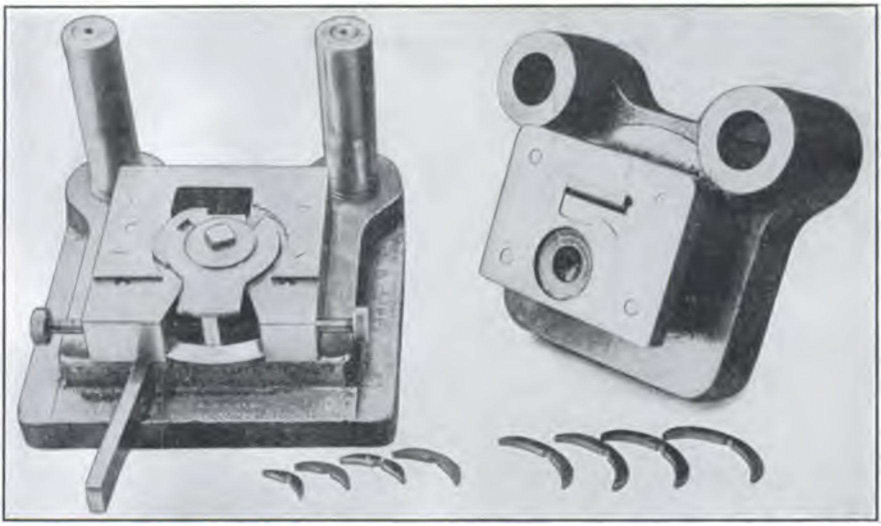


FIG. 201. — Trimming and shaving dies for steel cams

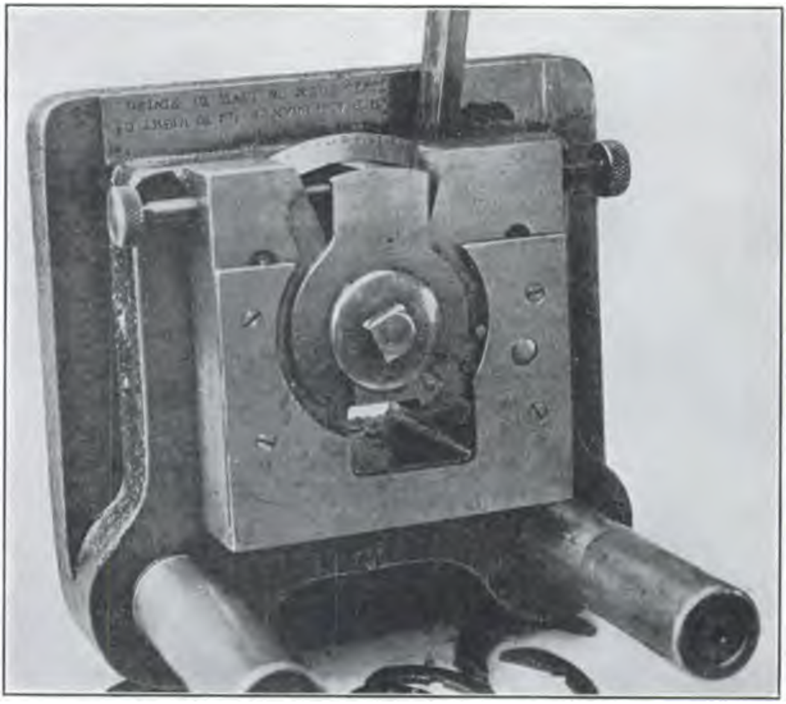


FIG. 202. — Face of cam die

the similar notch blanked in their concave sides. According to the detail, Fig. 197, this locating notch is made to a radius of $\frac{5}{64}$ in. and is 0.070 in. deep. When the adjustable nesting device B is set by the front graduations C to the right position, the cam placed in the nest will be cut off to desired length and form. After the entire lot for one length of cam has been trimmed, the device B is reset to another graduation C and the next length trimmed, and so on. This is brought out distinctly by the sketches, Figs. 204 and 205, which show the settings for two cams, one long and one

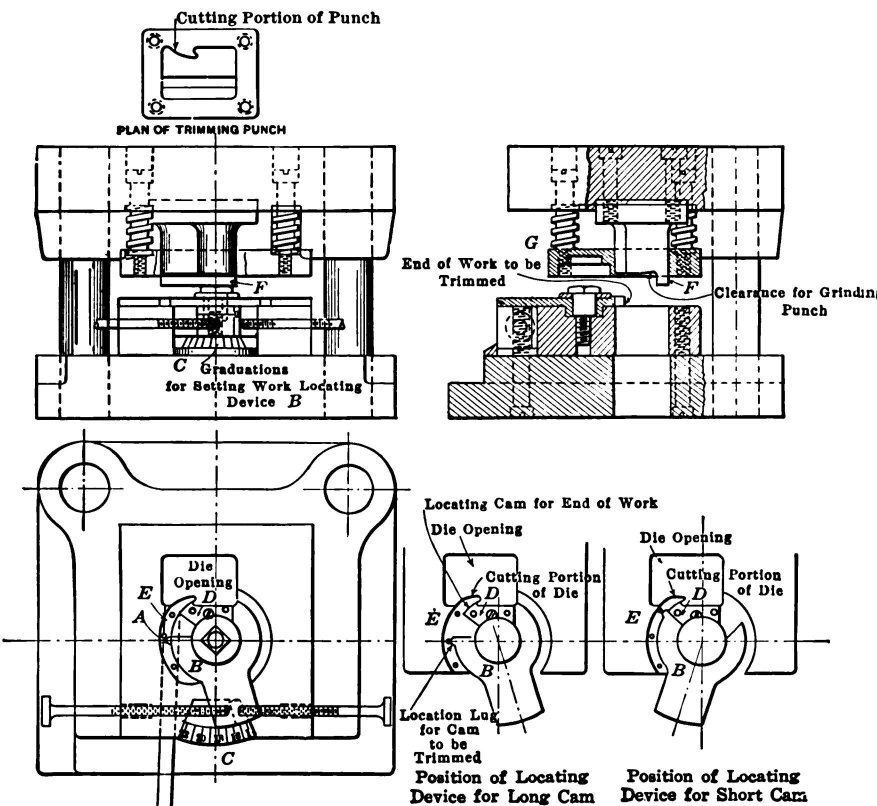


FIG. 203 FIG. 204 FIG. 205

FIGS. 203–205. — Trimming and shaving dies for steel cams

short, and indicate the amount of movement of device B in the change from one cam to the other. The intermediate settings possible are all established by the graduations on Plate C let into the front of the die shoe.

THE CUTTING EDGES

The front end of any cam trimmed in this die is located against stop gage D and as the blank cam rests closely in the circular channel or nest E

with its half round notch over the lug *A*, the work is well secured against shifting under the cut. This notch by the way is the locating medium for the finished cam when assembled in the calculating machine, hence the importance of finishing all ends from this central point. Both ends of each cam are trimmed alike, the blank being turned over for the cut on the opposite end.

The trimming punch has only a short length of cut but is itself of liberal proportions for rigidity. It fits at back and sides in the oblong die opening which acts as a further guide for retaining the punch in alinement. The back of the punch as indicated at *F* is $\frac{1}{4}$-in. longer than the face so that it has an opportunity to become well located in the die opening before the cutting edge strikes the work. The punch is enclosed in the spring controlled stripper and pressure pad *G* which holds the blank firmly during the trimming operation.

In operation, the die is first set for trimming the cams to specified length by bringing the vertical zero line *O* (on the wing under locator *B*) to within $\frac{1}{32}$ in. of the required graduation on scale *C*. This offset is enough to allow the dies to trim the cams longer than finish size by about 0.010 in. which amount is left for shaving in a second operation in the same dies. For the shaving cut, which is taken after the entire lot have been trimmed as above, the locating device *B* is reset exactly to the requisite graduation and the work run through as before for the removing of the thin chip which smooths the cam ends perfectly and brings them to exact length.

Trimming and Shaving Dies of the Progressive Order

There is one more type of die that should be of interest in this chapter—the progressive trimming and shaving arrangement illustrated by Figs. 206 to 208. These tools are for the manufacture of a small calculating machine key of the dimensions given on the part detail in the latter engraving. The material used is steel lengths about $\frac{1}{8}$-in. wide by 0.078-in. thick. The dies perform their work by cutting away the material from one side only, thus producing the piece complete by the trimming and shaving process.

The small key is finished 0.458-in. long and has a projection at one side 0.015-in. high by 0.090-in. wide. The method of running the stock through the dies will be understood upon examination of the plan views of the tools in Figs. 207 and 208.

The material is fed in through the narrow channel guide at the right of the die openings and with the first stroke of the press the trimming punch *A* takes a cut along the edge indicated at *A*1. At the next advance of the stock, the portion already trimmed is shaved as at edge *B*1 by the punch *B*, and the trimming punch *A* operates on the next cut. At the same stroke, the extension *C* on the shaving punch *B* cuts off the key at the point

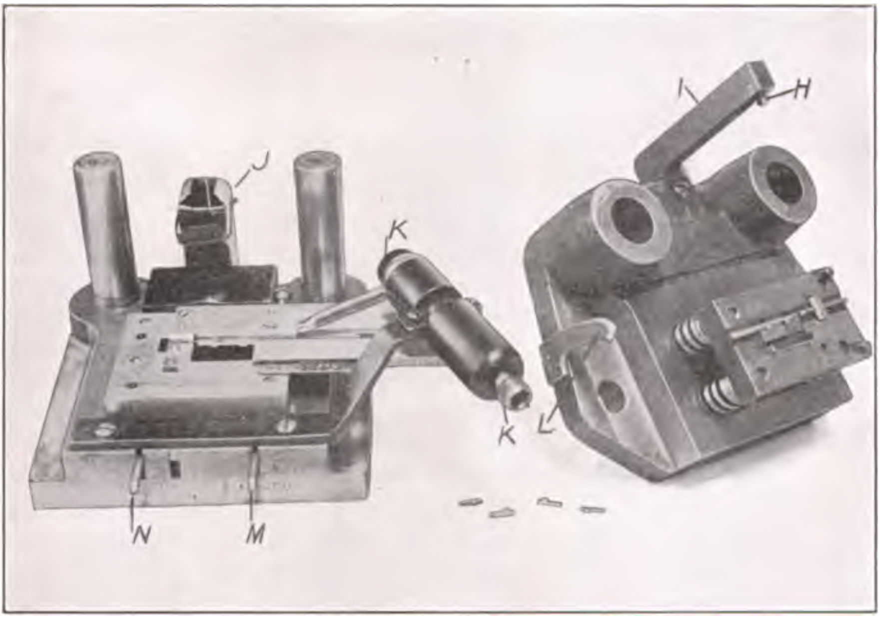


Fig. 206. — Trimming and shaving dies in progressive order

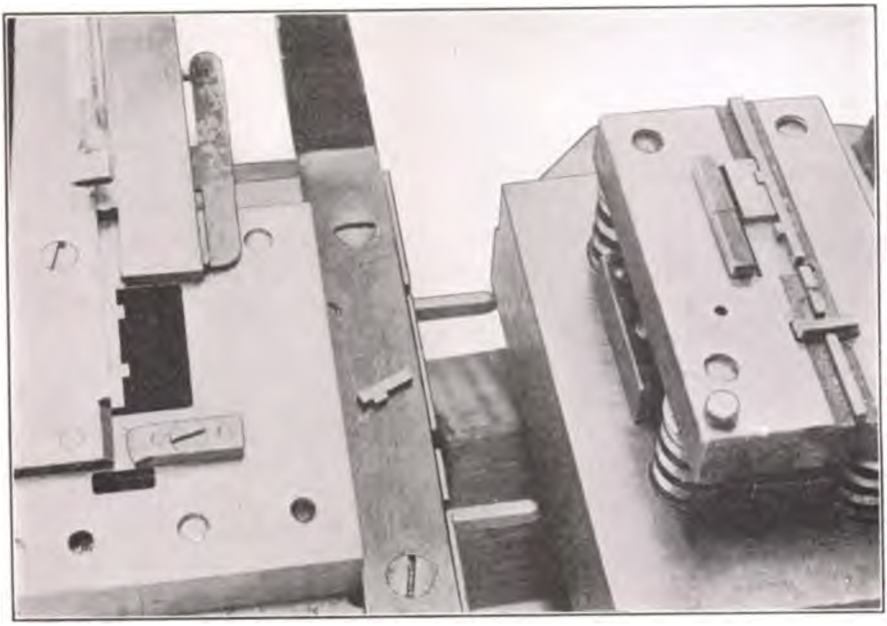


Fig. 207. — View of punch and die face

$C1$ and when the work is advanced to the third position the end of the key is trimmed by the punch D and die $D1$. Each succeeding stroke of the press then causes one portion of the stock to be trimmed closely to the key width, the preceding portion to be shaved to size and cut off, and the leading end of that piece to be shaved to length.

Some Details of Construction

The drawing, Fig. 208, shows the principal features of the tools but certain details are best seen in the photographic views, particularly the air

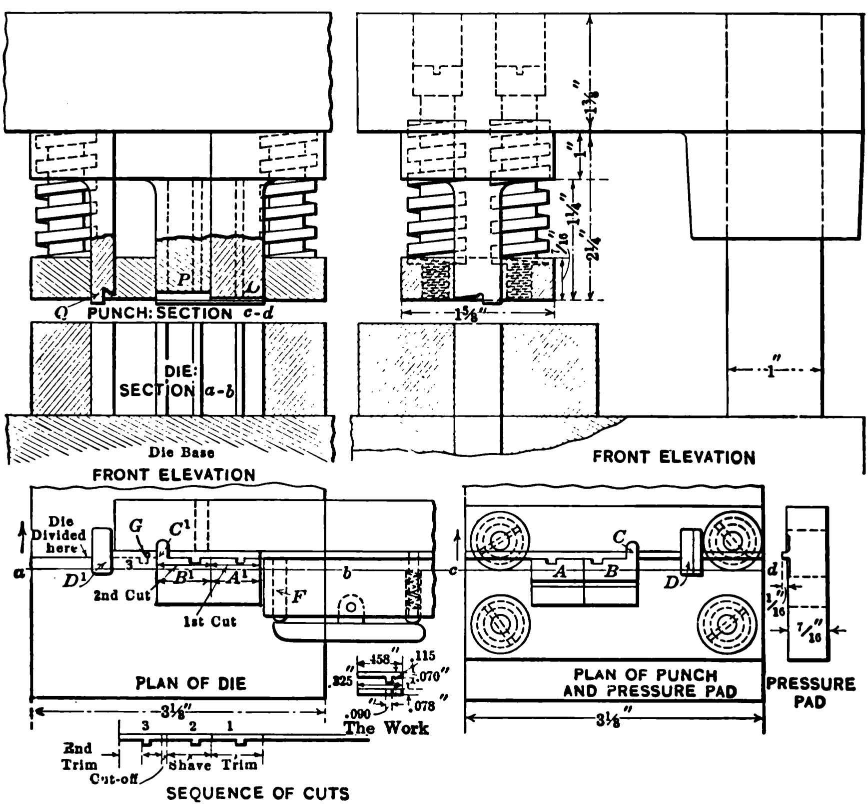


Fig. 208. — Progressive trimming and shaving die

nozzle and control for blowing the finished blank from the dies. The narrow strip of stock is pressed back to the guide by the spring actuated finger F at the front, this being shown by dotted lines in the plan view of the die in Fig. 208. At G is a small knock-out pin which is operated by a wedge-shaped member underneath to lift the finished work slightly and so allow the compressed air charge to blow the piece clear off the dies. The wedge for operating this is itself moved forward against spring pressure by

a pivoted latch *H*, Fig. 206, which is carried on a vertical arm *I* adapted to operate in tube *J* at the rear of the die. The pivoted piece *H* on the down stroke rocks up sufficiently to swing past the end of the operating wedge and on the ascent of the punch it drops back to its seat and acts against the end of the wedge which then slides forward and operates the knock-out pin *G*, Fig. 208.

The air nozzle is controlled by the plunger *K*, Fig. 206, and the hooked finger *L* on the punch head which acts upon the plunger head when the punch rises with the press slide. The stop for the first position of the stock is operated by lever *M*, and the second stop by lever *N*.

The Form of the Punches

The different views show clearly the form of the punches and stripper, as well as the die itself which is made in halves to facilitate construction. The trimming and shaving punches *O* and *P* are of different height of cut so that the trimming tool does its work before the shaving die strikes the stock. Both punches, and the end punch *Q* as well, are made with back portions extended downward sufficiently to enter the guides formed by the die openings before the cutting portion contacts with the work. The cutting edges are cleared as shown and the relief along the center of each punch end enables the tools to be ground readily.

Another set of dies of this same construction are used for trimming and shaving a longer key and here the punches are sheared from end to end to enable them to take the longer cut easily and with smoothest possible results. The shearing angle on these cutting edges is about 3 degrees.

The pressure pad and stripper for the punches shown is backed up by very heavy springs at the four corners and the pad face is milled away as represented to leave a narrow bearing surface along the face for contact with the work. This holds the narrow stock strip securely against possibility of rocking during the taking of the cuts along the one edge.

CHAPTER VIII

DRAWING DIES AND THEIR ACTION UPON MATERIALS

Press tools of this class, while used in almost infinite form and variety, are frequently found to be most difficult to make for entirely satisfactory operation. There are several factors entering into their use that have less weight with other classes of dies and which cause each set of drawing dies to be more or less of an individual problem for the tool maker.

In the first place, the character and quality of the material to be worked is an element of greater importance than with the majority of press tools and a set of drawing dies which might give perfect results with one grade of stock may be found anything but satisfactory when applied to another kind of material. The thickness of the metal is another factor that must be given unusual consideration for it has a most direct bearing upon the form that is to be given the edge or mouth of the drawing die, the radius of the corner at the drawing edge being usually based to a large degree, if not wholly, upon the gage of the stock to be drawn.

The division of the total length or depth of draw into a suitable number of intermediate operations is another feature of the problem. A shallow draw is one proposition; a deep draw another. The character of the metal worked is a determining factor here and the total number of draws and the corresponding number of tools in the entire outfit is a matter that is quite apt to be settled in accordance with the experience of the die maker who has the work in hand. With his knowledge of the limitations of various grades of stock he is enabled to arrive at results that cannot, as a rule, be obtained by merely following a layout that may or may not seem properly proportioned.

LIMITING FACTORS

If the attempt be made to draw the metal to too great a depth in each operation the material will be fractured or the bottom of the shell torn out. If the radius of the drawing die edge is too small the metal will be drawn too abruptly over the corner with probability of becoming stressed beyond its tensile strength and ruptured. If, on the other hand, the radius be too great the surface of the work is likely to become wrinkled in the drawing process due to the failure of the material to cling to the drawing surface. With the heavier gages of stock there can be corresponding increase in the radius of the drawing edge because of the tendency for the thicker metal to hold closer to the drawing surface.

If too little allowance is left between first operation drawing punch and die diameters, unsatisfactory results may be expected, for in such case the shell is likely to be fractured, and the wear on the die surface seriously increased, with the result that it becomes scratched and pitted through consequent improper lubrication, and the work is drawn with a scratched surface. If the depth of the drawing surface in the die is too great similar results will be produced. These are some of the considerations affecting punch and die construction for drawing operations, and they will be dealt with more fully, along with other features of importance, as this chapter develops.

Action of the Tools upon the Work

It is not always easy to analyze the action of drawing dies and the detailed effect of the drawing process upon the material. The following sketches may be of aid in this direction however.

Suppose we have, for example, a 3-in. disk of brass, *A*, Fig. 209, which is to be drawn in a single operation (for simplicity of illustration) to the shell form at *B*, which has a depth of $1\frac{1}{4}$ in. and a diameter measured at the center of the thickness of the wall of $1\frac{3}{8}$ in. These are the proportions to which such a blank would draw if no allowance be made for stretch in the stock and if the corners were square. Now let us consider what the combined effect of the punch and die will be when the round blank is pushed down through the die, or "drawn," as we say, into the shell *B*.

The punch we will consider as made smaller than the inside diameter of the die, by an amount equal to twice the thickness of the metal to be drawn, so that the latter will have space to retain its original thickness. The central portion of the blank, then, for a diameter equal to the size of the die opening, will be started down into the die much as though it were being punched out by a piercing punch except that the round corners of the punch and die and the liberal side clearance between the two tools will prevent the center from being cut out, and, as the punch continues to descend, all of the metal in the blank surrounding the central portion will be caused to follow down through the die and, in doing so, to flow along radial lines until the complete area of the ring of stock outside of the center which forms the bottom of the shell has been absorbed into the side walls of the shell.

Displacement of the Metal

The effect of this drawing process upon the structure of the blank disk of metal may, to a limited extent at least, be seen by reference to Fig. 210. Suppose that here we have placed a number of narrow strips of stock, *C*, *C*, *C*, which are of so light a gage that their thickness may be disregarded for the moment. These strips are spaced uniformly in a seat or nest at the top of the die and their width is such that their edges intersect at a distance from the center equal to the radius of the die opening below, which is here

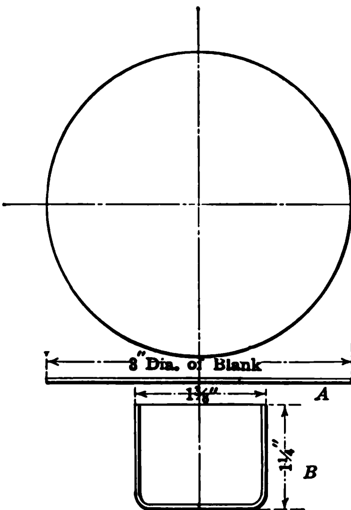


Fig. 209

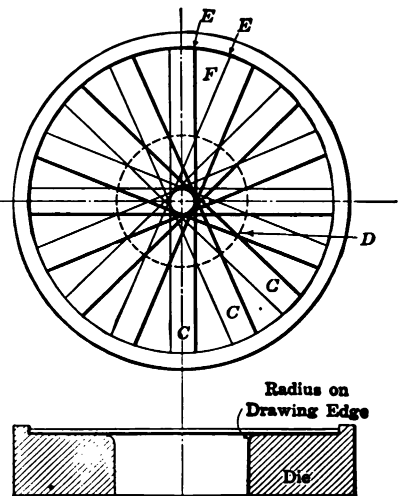


Fig. 210

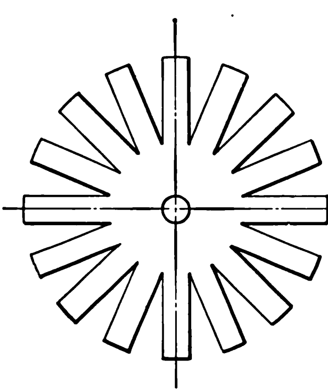


Fig. 212

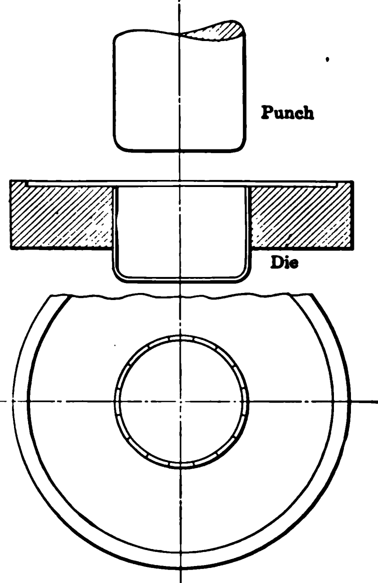


Fig. 211

Figs. 209–212. — Action of drawing dies

indicated by the dotted circle *D*. The punch is then allowed to descend and in so doing it forms up the series of crossed strips of metal into the shell in Fig. 211 where the vertical walls of the piece are composed of the formed up ends of the strips which are shown as abutting against one another. As these strips are bent down over the drawing edge of the die and pressed down through, their ends approach the die diameter, and, traveling along radial lines, their facing corners *E*, *E*, converge and the triangular space *F* between them grows smaller until it disappears completely with the arrival of the ends of the strips at the die opening upon the completion of the down stroke of the drawing punch.

Application to the Solid Disk

If we now transfer the pattern made up of the narrow strips in Fig. 210 to the plain disk, Fig. 209, and trim out the V sections between the lines, we obtain a spider effect, Fig. 212, with a center the size of the die and sixteen radiating arms. This blank may then be forced through the dies and formed into the same shape as the crossed strips, or again as represented by Fig. 211. But the process is not one of drawing, for no metal has been displaced or caused to flow under tension, and the shell wall formed by the series of vertical arms on the blank is merely the result of a forming or bending operation accomplished in the drawing die.

But, upon taking the plain disk, Fig. 209, and comparing its area with that of the spider in Fig. 212 and then forcing the former through the drawing die we are enabled to arrive at some conclusion as to the effect upon the blank under the drawing process. In this particular instance, the amount of material cut out of the blank in Fig. 212 will equal about 2 sq. in. or roughly 30 per cent of the original area of the plain disk. Therefore if this plain disk is drawn up as in Fig. 209, the above area of 2 sq. in., times the thickness of the stock is the amount of metal that has to be displaced by the flowing under tension and absorbed into the mass of the shell during the drawing operation.

The 30 per cent of material thus accounted for represents an exaggerated condition, in order that emphasis may be placed upon the peculiarities of the drawing process; under usual practice the first drawing operation, or the "cupping" so-called, from the blank to the first short shell or "cup" is not designed to produce a height of side wall of much over one-half the diameter of the shell, especially if the metal is $\frac{1}{16}$ in. or more in thickness. Therefore, if in approaching more closely to normal conditions we cut down the diameter of the blank to, say, about $2\frac{5}{16}$ in. (which would be the approximate size for a shell drawn to $1\frac{3}{8}$ in. diameter by $\frac{5}{8}$ in. high) we shall find that the excess of metal to be absorbed into the body of the shell as drawn through the die is only about one-half the above proportion, or 15 per cent.

The Lines of Movement

As already pointed out, the flowing of the metal in the blank disk, when subjected to the tension imparted by the drawing tools, is, generally speaking, along radial lines; although there would necessarily appear to be an accompanying lateral or annular flow throughout the body of the shell, particularly where the punch and die are so made as to leave a space between their surfaces equivalent only to the thickness of the stock. The result is a more densely compressed material with corresponding hardening of the metal which necessitates a resort to annealing processes before redrawing of the shell may be satisfactorily accomplished.

In reference to this allowance between the diameter of the punch and the inside wall of the die, it has been found desirable, particularly with first operation or cupping tools, to exceed the thickness of the metal to be drawn and allow from $2\frac{1}{4}$ to $2\frac{1}{2}$ times the stock thickness between punch and die diameters. A good many shops working on steel shell operations follow the practice of making drawing dies with only enough clearance between punch and die for the double thickness of material. In contrast with this custom, some most successful tools for cupping and several redrawing operations have been made for heavier work with the drawing die $\frac{1}{32}$ in. over size. This gives a die that works easily and which is not likely to become quickly scratched. The work drawn up is more easily ejected and where a close degree of uniformity of wall thickness is not essential the tools are operated with entire satisfaction. The material naturally is not subjected to such high stresses with the larger dies, and it will usually be found practicable to pass the work through an increased number of operations before annealing. Furthermore there is a tendency for the walls of the work to thicken up under these conditions which is a feature of value where increased strength is desired. And, the tools themselves being subjected to less severe service, are capable of correspondingly increased production.

The Drawing Edge of the Die

The drawing process starts with the forcing down of the material over the edge of the die and it is at this point that difficulty is likely to commence, either with wrinkling of the work or in fracture of the shell as it is drawn down through the die. As stated in the opening paragraphs, too small a radius at the drawing edge, too sharp a corner, puts the material under undue stress and may lead to rupture; although this radius should be held to a low dimension when an even-ended shell is to be produced in a single operation. As the radius of edge is generally established for a given material by the thickness of the stock, the radius for thin material may be quite small. Some die makers recommend a rule for fixing the radius at

from six to ten times the thickness of the material, but even this allows a wide latitude for individual judgment and there are numerous instances where considerable departure must be made in one direction or the other from the above suggestion.

The simplest type of blanking outfit, one for first operation, the production of a shallow cup from a round disk, is represented by Fig. 213. The die in this instance has a seat, or nest for the reception of the blank disk, and the nest surface and die opening are connected by the liberal round corner indicated so that the material will draw down readily into the die. When the punch has completed its downward movement and commences to rise the shallow cup is stripped from the end of the punch by the sharp lower edge of the die and falls out of the press.

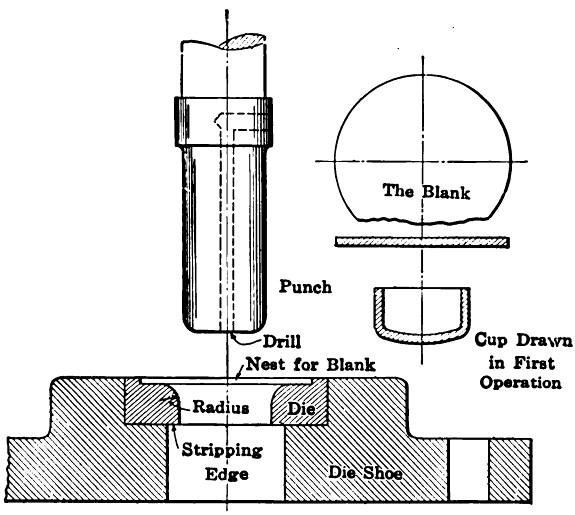


FIG. 213. — Typical drawing die construction

This form of die is suited only to the making of shallow draws for it carries no pressure plate or blank holder to apply pressure to the surface of the material and so prevent wrinkling of the work as it is drawn down over the die edge. The use of the pressure plate is an essential for general drawing operations as it "irons" out the surface of the work between its face and the opposing face of the die to eliminate wrinkles in the metal. The degree of pressure applied to the material must, however, be regulated with judgment, otherwise the metal will be strained unduly in passing over the radius of the drawing edge of the die and this may lead to the work breaking when passed through subsequent operations.

General Types of Drawing Dies

Besides the simple form of die illustrated in Fig. 213 there are a number of types that are used extensively, some of them of a relatively complicated character. In contrast to the non-blanking dies just referred to, they are commonly constructed to cut their own blank and perform the first drawing operation at a single stroke of the press. Such tools may be classed as double action cutting and drawing dies for use in double action presses;

combination dies for operation in single action presses; triple action dies (which include a further operation of embossing or otherwise working the bottom of the drawn piece) which are used in triple action presses.

Redrawing dies of "push through" type are quite similar to the first operation or cupping tools, Fig. 213, except that they are adapted to receive the formed cup instead of the flat round blank, and to redraw the cup to the desired length and diameter by a series of operations in as many dies.

Double action dies are made both of the open or "push through" type and of solid bottom design. They each perform the combined operations of blanking and drawing in the one stroke.

General Principles of Double Action Tools

These two types of double acting dies are illustrated by Figs. 214 and 215 respectively. The double acting presses in which they are used are made with two slides, an outer slide which carries the combined cutting

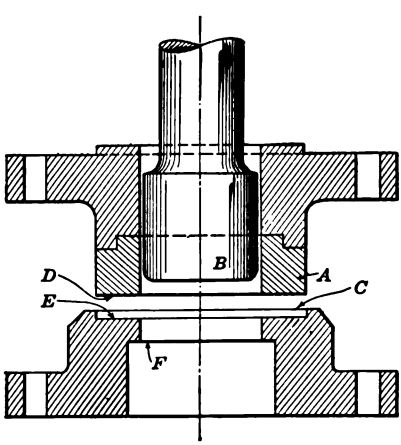


Fig. 214. — Double action cutting and drawing die: "Push through" type

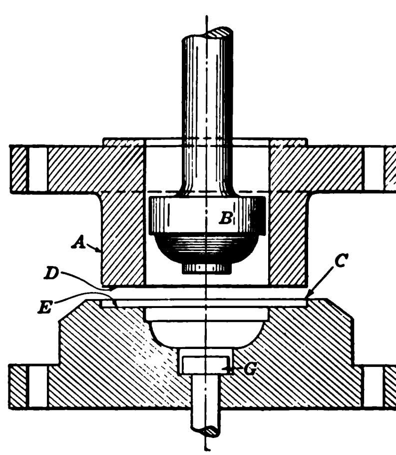


Fig. 215. — Double action cutting and drawing die: "Closed bottom" type

punch and blank holder *A* and which moves slightly in advance of the inner slide which carries the drawing punch *B*. The outer slide of the double action press is so controlled that after making its stroke downward it stops during about one-quarter of the revolution of the crank shaft.

The blank disk having been cut from the sheet by the edges of punch *A* and die *C* drops into the nest in the upper face of die *C* and is there held between the annular pressure surfaces *D* and *E* during the down dwell of the outer slide. While the blank is thus held under pressure that can be regulated to suit the requirements of any given case, the drawing punch *B* continues its downward movement under the action of the inner slide

and draws the metal from between the pressure surfaces *D* and *E* into the shape desired. In this manner wrinkling is prevented.

For work which is straight-sided, cylindrical, or prismatic and which conforms to the shape of the punch without requiring a counterpart in the bottom of the lower die, tools of the push through type, Fig. 214, are used. They admit of pushing the finished work down through the die, the article being stripped from the punch at the beginning of its up stroke by the stripping edge *F*.

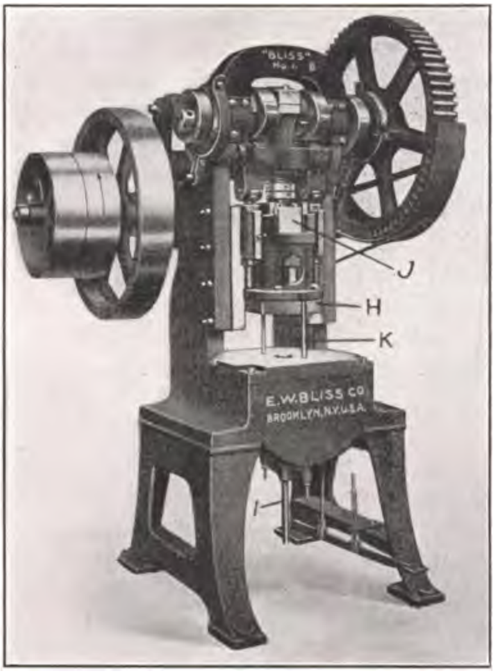


FIG. 216. — Double action press

Where a counter pressure in the lower die is necessary the closed bottom type of tool, Fig. 215, is used. These dies have in addition to the lower die, blank holder, and drawing punch, a push out plate or "knock out" *G* which is arranged to rise at the same time as the blank holder *D* and thus lift the work from the die.

Examination of the view of the double acting press in Fig. 216 will show the method of controlling the dies just described. This design of press makes use of cams for actuating the outer slide *H* and the blank cutter and holder, while the inner slide *J* with the drawing punch is crank operated. The cams are shaped to give any desired period of dwell and the pressure of the blank holder upon the work may be regulated to suit the requirements of the operation. Double action presses are also made with two outer cranks for operating the outer slide with the blank holder. Also they are built with toggle action for the operation of the outer slide, these being used more especially for the larger and heavier drawing operations.

This view of the press also illustrates the arrangement of the knock out apparatus *K* attached to the blank holder for lifting the work from the lower die where solid bottom dies, like Fig. 215, are employed.

Triple Action Dies

Triple action dies operate the same as double action tools so far as concerns the blanking, blank holding, and drawing operations, but as the name indicates they add a third operation which may be the embossing, stamping, or special forming of the underside of the work, which is accomplished in the triple action press by a lower plunger under the bed which rises to meet the work as it is drawn through the main die. On the up stroke the work is stripped from the drawing punch by the stripping edge under the lower die and it can then be removed from the opening in the side of the raised bolster. A set of dies of this type with brief description is shown in connection with Fig. 25, Chapter I.

Combination Dies

Combination dies are used extensively for such work as cutting a blank, turning down its edge, and forming it into shape all at one operation. In appearance and method of operation such tools bear a close resemblance to compound dies. They are described at length in Chapter IX. Dies of this class are usually so arranged that the finished work is ejected from the die by the action of springs, and where an inclined press is used the finished article will slide back out of the machine by gravity.

Dies for Drawing Shells

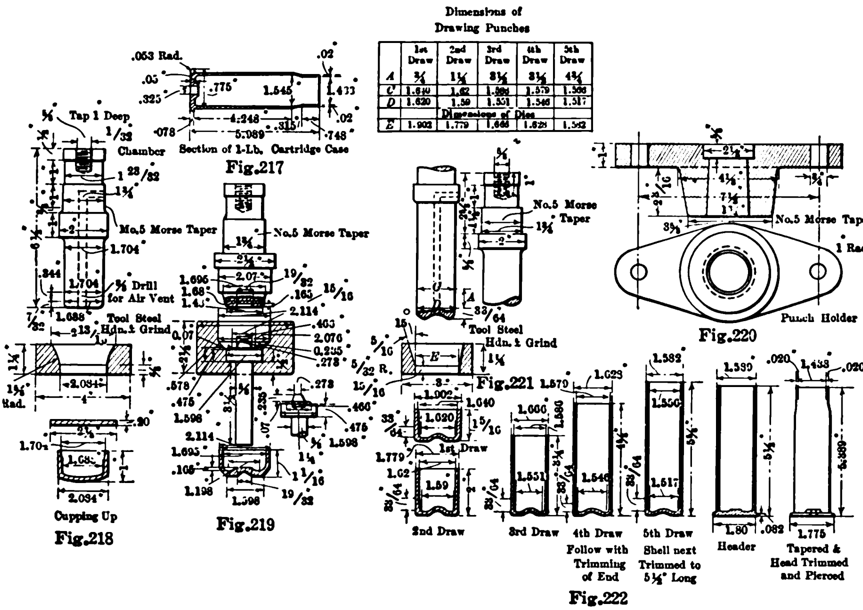
One of the most common uses for drawing dies is found in the manufacture of cases for rifle cartridges, and for the various sizes of shells for larger ammunition. These are of the general type illustrated by Fig. 213, which shows a first operation set for forming up a shallow cup which is afterward extended to length by a number of drawing operations.

The drawings that immediately follow represent in detail the press tools for producing 1-lb. cartridge cases, dimensions of which are given in Fig. 217. The case is of brass composed of 70 per cent copper and 30 per cent zinc. It has an over-all length of 5.389 in. and a diameter at the mouth of 1.433 in., inside.

The shell is drawn up from a cup made from a disk of metal 0.20 in. thick by $2\frac{7}{8}$ in. in diameter. The disk, the cup, and the cupping tools are all shown in detail in Fig. 218. The cupping operation forms the blank disk into a shallow cup 2.084 in. diameter by 1 in. long. It will be of interest to note the form of the die for this operation. The die body is $1\frac{1}{4}$ in. thick but the drawing surface, the straight portion below the radius, is only $\frac{3}{8}$ in. deep. The remainder of the depth is taken up by the round corner or drawing edge over which the material is worked as it is pressed down through the die.

The radius of this corner is $1\frac{5}{8}$ in. or eight times the thickness of the

stock, so that it falls well within the rule recommended above for allowing between six and ten times the stock thickness for the cup die radius. The straight portion of the die, as with the other dies in the set, is limited as noted, for it is not desirable that drawing dies have too long a reducing surface as this is likely to result in the work becoming heated to excess in passing through the die, thus preventing proper lubrication and causing particles of



FIGS. 217–222. — Tools for drawing 1 lb. cartridge cases

the material to adhere to the die surface until the accumulation with the progress of the work will bring about a condition where the shells will be scratched along their length, if not broken in the operation.

Die Shoes and Punch Holders

The die is held in the shoe or bolster, Fig. 223, and the retainer plate, Fig. 224, is used for receiving the blank disk for cupping. Both shoe and retainer plate are shown with tables of dimensions to which the openings are bored to receive the different dies and shells, for the same pattern is used for the different sizes of parts entered therein.

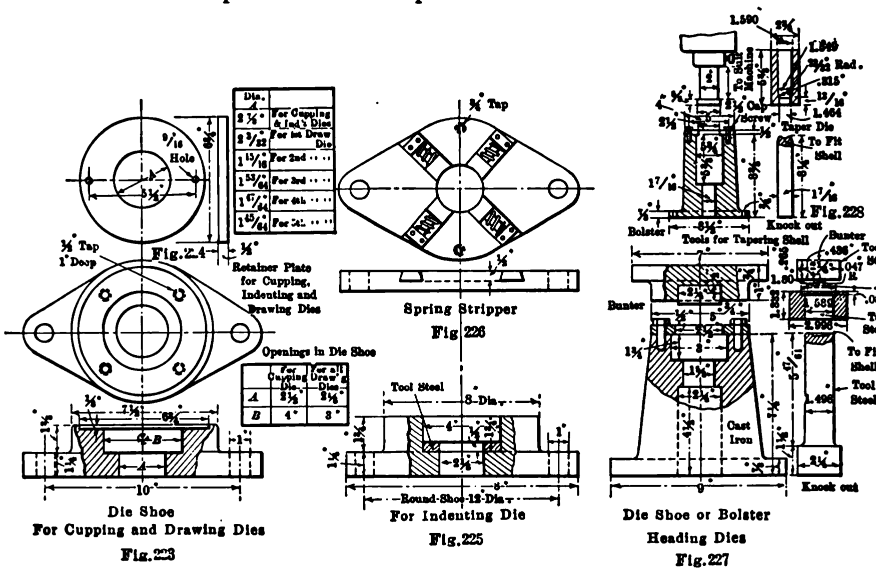
The cupping punch, Fig. 218, is adapted to be carried in the punch holder, Fig. 220, which is bored to a No. 5 Morse taper, this form of shank being used on all the punches in the series.

The indenting die, Fig. 219, while not a drawing device is shown here as a part of the press equipment which follows the cupping operation in preparing the work for the actual process of drawing. As indicated in the

drawing, it forms up and indents the base of the shell to prepare a cavity which is later machined out to receive the primer. The indenting die is used in the shoe, Fig. 225.

Before this indenting operation is performed and before each of the subsequent drawing operations, the work is annealed and pickled, the annealing being accomplished in this instance in a gas heated oven regulated by a pyrometer where the shells placed on trays are submitted to an average temperature of about 1350° F. The work remains in the oven for 30 minutes and is then washed in pickling compound to remove the scale.

Further reference to annealing and pickling of such material will be made at another point in this chapter.



FIGS. 223–228. — Tools for drawing 1 lb. cartridge cases

THE DRAWING TOOLS

There are five drawing operations which follow the indenting of the shell, and the details of punches and dies for the work are given in Fig. 221, where the table at the side of the punch and die layout gives the important dimensions of the various tools in the series. The drawing, Fig. 222, shows the shell in its different stages as it progresses toward completion. The punches are carried in holders, like Fig. 220, the dies in shoes or bolsters like Fig. 223. From the second drawing on, the spring stripper, Fig. 226, is used.

Following the fourth drawing operation the end of the shell is trimmed and after the fifth draw it is trimmed again to length. Then it is headed by the tools shown in Fig. 227, the open end is annealed and the taper formed by the dies, Fig. 228.

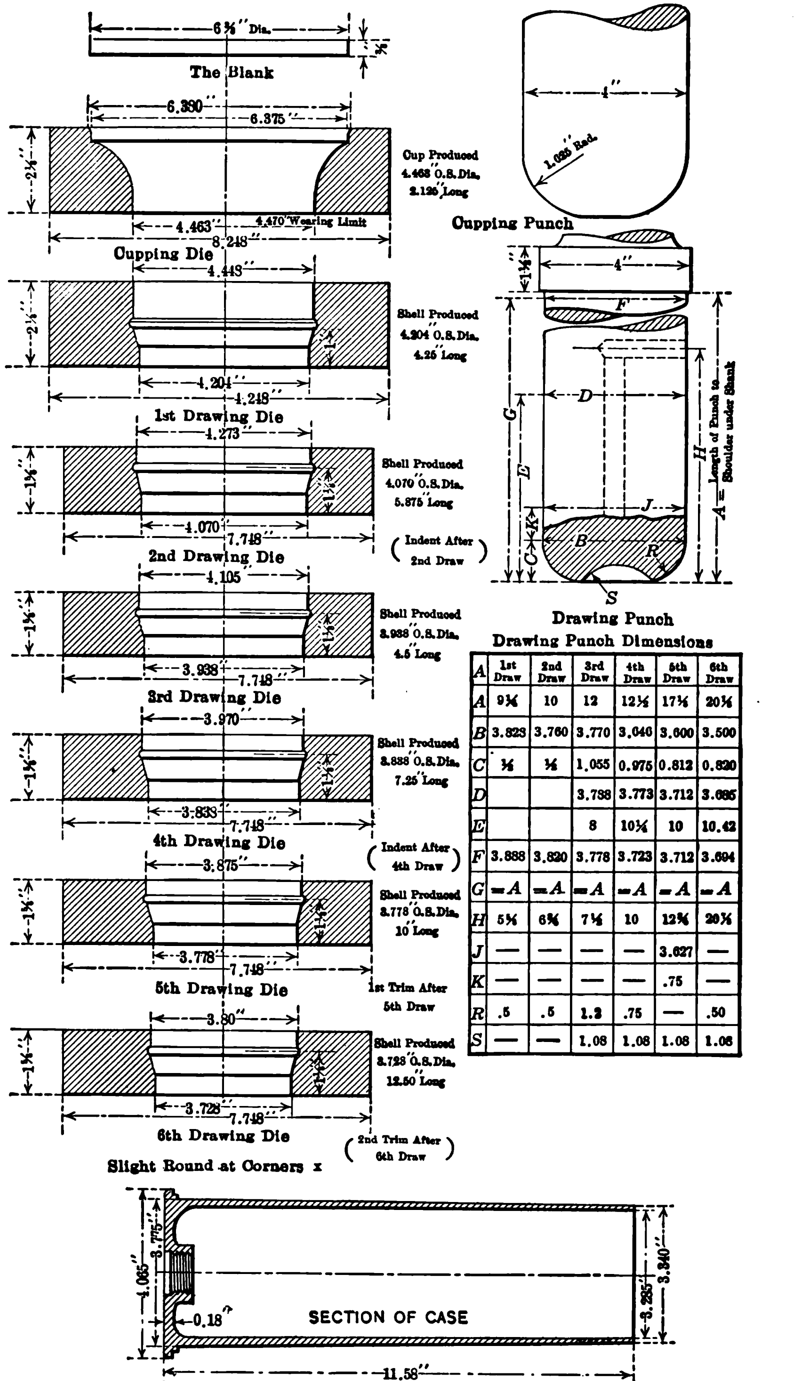
The operations of finishing the flange or head, the machining to length, the forming of the primer hole and recess are not performed in press tools and need not be described here. It is believed however that it will be of value for purposes of reference to include here the complete schedule of operations in this shell manufacture and the accompanying table is accordingly reproduced. The items marked with an asterisk are press operations.

Schedule of Operations on Shells

1. * Blank.
2. * Cup. Punch and Die, Fig. 218; Punch Holder, Fig. 220; Bolster, Fig. 223; Retainer Plate, Fig. 224.
3. Anneal and Pickle.
4. * Indent. Punch and Die, Fig. 219; Punch Holder, Fig. 220; Bolster, Fig. 225; Retainer Plate, Fig. 224.
5. Anneal and Pickle.
6. * First Draw. Punch and Die, Fig. 221; Punch Holder, Fig. 220; Bolster, Fig. 223; Retainer Plate, Fig. 224.
7. Anneal and Pickle.
8. * Second Draw. Punch and Die, Fig. 221; Punch Holder, Fig. 220; Bolster, Fig. 223; Retainer Plate, Fig. 224; Stripper, Fig. 226.
9. Anneal and Pickle.
10. * Third Draw. Punch and Die, Fig. 221; Punch Holder, Fig. 220; Bolster, Fig. 223; Retainer Plate, Fig. 224; Stripper, Fig. 226.
11. Anneal and Pickle.
12. * Fourth Draw. Punch and Die, Fig. 221; Punch Holder, Fig. 220; Bolster, Fig. 223; Retainer Plate, Fig. 224; Stripper, Fig. 226.
13. Trim to Length.
14. Anneal and Pickle.
15. * Fifth Draw. Punch and Die, Fig. 221; Punch Holder, Fig. 220; Bolster, Fig. 223; Retainer Plate, Fig. 224; Stripper, Fig. 226.
16. Trim to Length.
17. * Head. All Tools in Fig. 227.
18. Anneal Open End and Wash.
19. * Form Taper. All Tools in Fig. 228.
20. Face and Finish Machine. Flange and Rough Out Primer Hole.
21. Machine to Length.
22. Burr Inside of Primer Hole.
23. Finish-Machine Primer Hole and Form Recess.
24. Wash.
25. Final Inspection.
26. Stamp.
27. Pack for Shipment.

The Form of the Drawing Dies

It will be noticed that all of the drawing dies for this case are made as in Fig. 221 with $\frac{5}{16}$ in. depth of drawing or reducing surface and the portion immediately above is bell mouthed out to an angle of 15 degrees on a side from the vertical. The corners are, of course, lapped off to dispose of the



Drawing Punch Dimensions

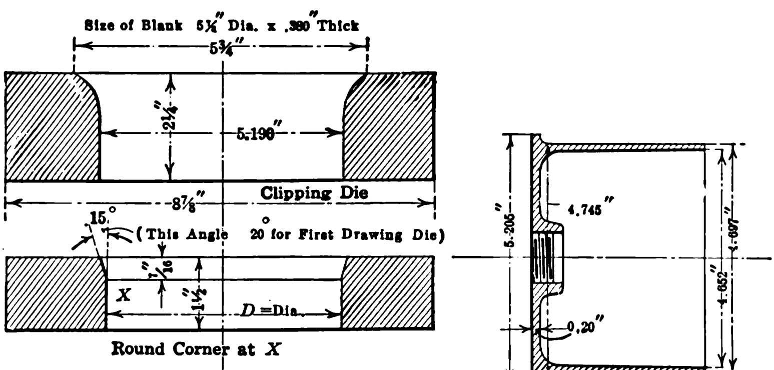
A	1st Draw	2nd Draw	3rd Draw	4th Draw	5th Draw	6th Draw
A	9¼	10	12	12½	17⅛	20⅛
B	3.823	3.760	3.770	3.040	3.600	3.500
C	⅛	⅛	1.055	0.975	0.812	0.820
D			3.738	3.773	3.712	3.686
E			8	10¼	10	10.42
F	3.888	3.820	3.778	3.723	3.712	3.694
G	= A	= A	= A	= A	= A	= A
H	5⅛	6⅜	7⅛	10	12⅜	20⅛
J	—	—	—	—	3.627	—
K	—	—	—	—	.75	—
R	.5	.5	1.2	.75	—	.50
S	—	—	1.08	1.08	1.08	1.08

FIG. 229. — Drawing dies for 18 lb. cartridge cases

sharp edge at the drawing point and it is also important that the working surfaces of die and punch be very hard and smooth to avoid possibility of rapid wear and defacing of the surface of the work.

The question of reduction in successive drawing operations, or the percentage of total reduction to be accomplished by each set of dies is of importance and a number of illustrations are here given, showing dimensions of other drawing dies operating on similar products. From these can be gathered the successive steps in producing the completely drawn shell, as well as the details of the form of the interior of the die.

Thus Fig. 229 shows a set of drawing dies for an 18-lb. cartridge case, the series of sections included in the drawing starting with the cupping die and covering the six drawing dies in the series. The notation at the side



Dia.-D for the Five Drawing Dies				
1st Draw	2nd Draw	3rd Draw	4th Draw	5th Draw
5.020"	4.898"	4.800"	4.725"	4.718"

FIG. 230. — Drawing dies for 4.5 Howitzer cases

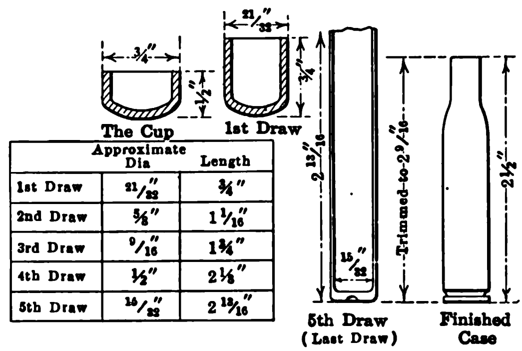
of the sketches gives the outside dimensions of the shell as it progresses from cup to final drawing, and the table gives the dimensions of the corresponding series of drawing punches. The latter will be seen to be tapered back from the end by an amount averaging about 0.010 in. per in. of length and various sets of tools measured for different work of similar nature are tapered in about the same proportion, though this taper is apt to run, as a rule, somewhat less to the inch for the longer draws and the final punch and correspondingly more for the first punches. For example, in the case of one set of tools for practically the same size of shell, the taper ranges from 0.020 per in. for the first drawing punch to 0.010 in. for the sixth or final drawing punch. These figures apply to the working portions of the punches, the total length of which measured under the shoulder is considerably greater than the actual depth of the shell drawn.

The sketch and table, Fig. 230, give the dimensions of the cupping and

drawing dies for a 4.5 howitzer cartridge case which is a comparatively short shell but which is nevertheless passed through five drawing dies after the cupping of the blank is accomplished. These dies have a working surface somewhat deeper than usual but the draw at each operation is very short as compared with the majority of work of the same character.

Smaller Work

In drawing smaller cases — as for 0.30 caliber rifle cartridges, a blank is used which is $1\frac{1}{16}$ in. diameter by 0.808 in. thick. This is formed into a cup $\frac{3}{4}$ in. diameter by $\frac{1}{2}$ in. long and the first drawing operation produces a shell $\frac{21}{32}$ in. diameter by $\frac{3}{4}$ in. long. The sketch, Fig. 231, shows the successive stages of drawing. As with the larger cases, these shells are annealed before each of the drawing operations.



	Approximate Dia	Length
1st Draw	$\frac{21}{32}$"	$\frac{3}{4}$"
2nd Draw	$\frac{5}{8}$"	$1\frac{1}{16}$"
3rd Draw	$\frac{9}{16}$"	$1\frac{3}{4}$"
4th Draw	$\frac{1}{2}$"	$2\frac{1}{8}$"
5th Draw	$\frac{15}{32}$"	$2\frac{13}{16}$"

Fig. 231. — Drawing operation on .30 cartridge cases

A design of blanking and cupping die, recommended by an authority for this class of work, is shown in Fig. 232. Here *A* is the die which is made with as large a cupping radius as possible to allow the shell to draw easily. The bottom of the die is relieved and the square edge *A* forms a good stripper which is positive in its action as the shell will expand enough after it has been drawn through the die to prevent it from going back up through the die when the punch returns. This die is secured in a holder *B* by retaining ring *C*, which is threaded and screwed into the holder.

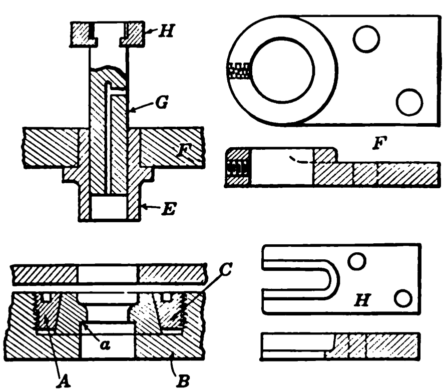


Fig. 232. — Blanking and cupping tools for rifle cartridge cases

The part *D* is a stripper of the ordinary type for the blanking die and punch *E* which is secured in the drop forged holder *F*, a detail of which is shown to the right. The drawing punch *G* has a vent hole the same as the other punches illustrated, to prevent trouble with the shells sticking to the ends of the punch because of the vacuum held by the fit of the work to the punch surface. It will be noticed that the top of the punch is slotted crosswise on opposite sides to receive the jaws of a holder *H* on the press

slide. This provides a floating connection, as the holders may be clamped in position and the holes for *F* and *H* tapped in their respective punch holder plates. The floating drawing punch holder is shown in detail *H* at the right in Fig. 232.

On work of this class it is customary to operate the blanking and cupping tools on the multiple principle with either two or four sets of dies in the double acting press.

Proper Vent in Punch Necessary

Reference may again be made here to the necessity of properly venting the drawing punch on work of this character. Besides the trouble likely to be caused by the shell sticking to the punch when the air cannot escape, there is occasionally difficulty brought about by insufficient passage room for the lubricating liquid. An instance of this kind recently brought to attention in a shop handling various classes of shell drawing operations is illustrated by Fig. 233. This is an explanation of some of the so-called "freak" shells that are now and then produced:

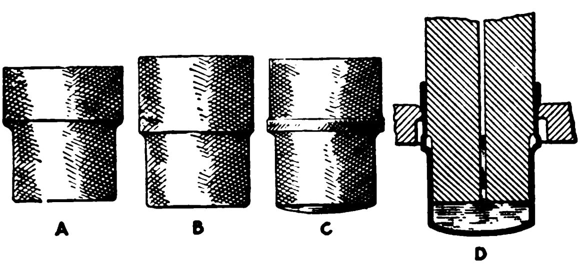


Fig. 233. — A freak shell and how it was made

In the engraving, views *A* and *B* show a certain kind of shell as it should be drawn and *C* represents a freak form discovered sometimes in putting through a lot of these shells. This was caused during the redrawing of the large diameter by an unusual amount of soap water used as a lubricant and occasionally left in the bottom of the shell. As the solution could not escape through the air hole in the ram when the punch descended, the result was that the solution ahead of the punch acted upon the shell in the manner indicated at *D*. This in turn caused the bulged part of the shell to be forced through the redrawing die without being operated on by the punch, which, in turn, caused this part of the shell to bulge after it was forced through the working part or edge of the die.

This trouble was remedied by drilling a larger air hole in the punch to allow the water to escape, and using care to keep the lubricant out of the shells as far as possible preparatory to feeding them to the die.

One Method of Cupping Thick Metal

Double acting presses and combination dies are not always available or practicable for certain work that comes along and when it is necessary to draw a shell from thick stock without such facilities a safe and efficient

method is to blank the piece first and then cup it by means of tools similar to those shown in Fig. 234. Here the drawing die is shown at *C*, the punch at *D*, the bolster at *E*, and the stripper at *F*.

The blank is inserted into the nest *G* as provided, after which the stripper *F* is screwed down onto the blank to create pressure much the same as when a double acting press is used. This method has given perfectly satisfactory results, although, of course, it is necessarily slow as compared with the operation of similar work in the usual equipment.

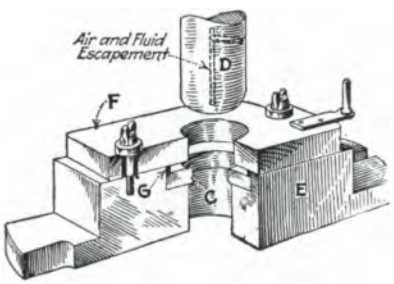


FIG. 234. — Clamp plate on die

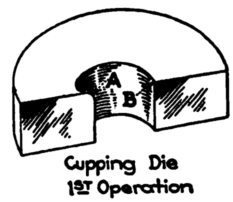


FIG. 235

A Comparison of Die Edges

Too much emphasis cannot be placed upon the importance of properly shaped die edges, and although reference has already been made to this point, it may be well to present here a comparison of proper and improper drawing edges.

Thus in Fig. 235 a sectional view of a cupping die is given, showing a liberal radius at *A* while an improper sharp corner is seen at *B*. As noted

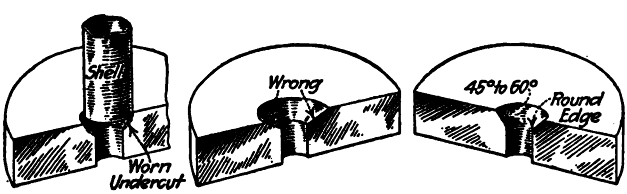


FIG. 236. — Shell drawing dies

in preceding pages, such a corner would result in causing undue stress in the material and if the tensile strength of the stock were exceeded the shell would be ruptured or fractured.

Referring to Fig. 236, all sharpness of the edges at the drawing point in a drawing die should be avoided and too abrupt angles or leads should not be permitted. Thus the slope of the angle in the mouth of drawing die *C* is shown with nicely rounded corner to allow the metal to draw or flow properly. However, after the die has been in service for some time it may be noticed that the shell has become shorter, owing to the wearing down or undercutting of this edge as indicated at *D*.

Annealing and Pickling of Brass Shells

In this section relating to the drawing of brass shells it may be well to include a few notes in reference to the annealing and pickling operations which are generally so essential between the successive draws for the production of satisfactory work and the preservation of the drawing tools.

While annealing is sometimes eliminated preparatory to a reduction, it is not advisable usually, for the material then becomes too hard and brittle, particularly when thin stock is drawn. The work is then severe upon the dies and in cases, like the redrawing of shells, say, $\frac{5}{16}$ diameter by 4 in. long, of 0.010-in. stock, it has been noticed that the product is inclined to be crooked or bent when not previously annealed. Another condition that will result in bent shells is having the back of the die broken out; this naturally does not occur when the diameter of the shell is large or it is drawn from thick stock.

Pitting of the die, scratched work, and shell breakage are largely attributed to lack of sufficient precaution in this direction. Too little annealing is as detrimental as its extreme, and should the annealing be insufficient (1000 to 1100 F. is usually about correct), the bottom of the shell is likely to punch out; the die will pit very easily. On the other hand, work that has been subjected to too high a temperature has decreased ductility and tensile strength. Under this latter condition a shell may or may not draw to its full length, although should no breakage occur, the smooth finish that is most desirable is lacking, and in its place appears an uneven, scaly product.

Care Necessary in Annealing

Extreme care should be used in annealing. If a pyrometer is not available, adjust the furnace until it shows a bright red glow, allowing the work to remain therein a sufficient length of time to bring all pieces to a like color, say, a cherry red.

If the temperature of the furnace is not increased, the work will not become overheated, even though the shells are allowed to remain in it longer than the predetermined time. Use sheet iron pans with covers, to prevent oxidation of the work and lessen the labor of pickling, but see that the shells are free from soap or oil and that they are washed thoroughly before the annealing operation. After the annealing the work is pickled in order to remove all evidence of scale or oxidation, and it should be remembered that the same degree of caution is required as for the annealing process.

The Pickle Bath

For the pickle, ten parts of water to one of sulphuric acid gives a satisfactory mixture for warm pickle; but if cold, seven parts of water to one of sulphuric acid is a good combination. This, however, may be mixed to

suit conditions. In preparing the bath always put the water in first, the acid last, the chemical action making this precaution necessary.

After all oxidation is removed, the shells should be immersed and washed thoroughly in hot or boiling water. Lukewarm water will not suffice. The equipment for this should consist of a wooden tank with provision for an outlet and an inlet for a continuous supply of clear water. Should this operation be improperly performed and the work be exposed to the air, it will be noticed that reddish spots appear upon the surface of the shells, and in some instances a green sediment or verdigris, which is nothing but the acid, a condition to be particularly avoided. The shells on top may not appear to be as mentioned, but investigation of the work halfway down or at the bottom will surely result in this finding.

Effect of the Acid on the Tools

It is needless to state that the acid has quite an affinity for steel; and should the work in the condition mentioned be redrawn, not much progress will be made as the tools will become pitted almost immediately and eventually ruined.

Suppose acid spots have not made their appearance; this does not necessarily mean that the work is clean. Shells are improperly cleaned so long as there is a vestige of scale or oxidation upon them, and it is then time to strengthen the mixture or to investigate the methods of the workman, who perhaps has passed the shells in too great a hurry.

The redrawing of shells that have any oxidation upon them is simply impracticable and profitless. Aside from the wear caused on the tools, difficulty will be encountered in the plating or finishing department with the bright dipping or plating as the case may be, all because the scale has been ironed into the surface of the shell by the drawing process.

A good way to prevent the oxygen from acting upon the shells is to immerse them in a receptacle of some kind filled with water or a soap mixture. Attached to it should be a pipe for heating. If there is any acid on the shells it will soon rise to the surface in a curdled state, where it is very readily skimmed off.

Redrawing tools should always be kept in a perfectly smooth, brightly polished condition so far as possible to assure satisfactory operation; but if conditions exist such as noted above even this care of the punches and dies will be of little avail.

Experience with Steel Shells

There is some difference of opinion in respect to the relative difficulties of drawing brass and steel shells, particularly in reference to the annealing operations required. It has been the observation of some that in cupping and deep drawing of sheet metal, steel can be drawn deeper than brass

without annealing although the first draw on a brass shell can be made slightly deeper than steel. It is necessary to run the press a little slower for steel than for brass.

In Fig. 237, at *A* and *B*, are shown some steel shells which were made in one operation. Those at *C* and *D* require two draws although at times material has been available from which these could be drawn in one operation. The largest of these shells have always been made in two draws, and the same shop is now using two draws on all shells that have a length equal to the diameter. After trimming, the large shells are threaded but there is no annealing between operations. It is believed that if the shells were of brass it would be necessary to anneal them after the first operation.

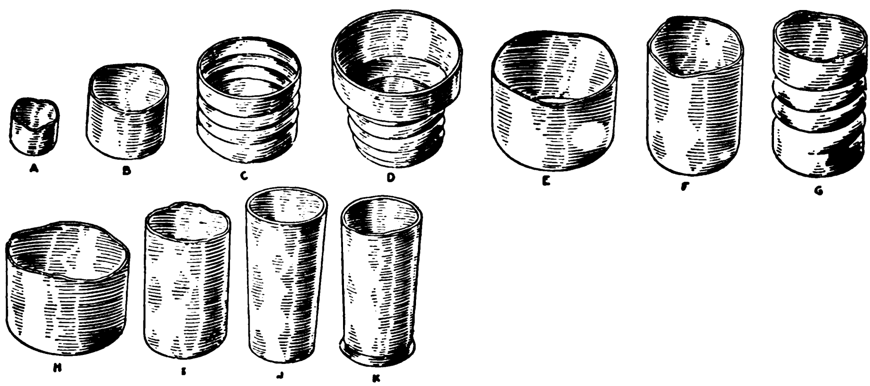


FIG. 237. — Steel shells drawn without annealing

At *E*, *F*, and *G* are shown the three operations necessary to make the piece from 0.018-in. cold rolled steel. There are two draws followed by rolling of the thread but no annealing is done between operations.

From *H* to *K* are shown the successive steps in making a screw driver ferrule of 0.030-in. cold rolled steel. This is also made without annealing, but if it were of brass it would be necessary to anneal it at least once.

Two Methods of Drawing a Deep Flanged Steel Shell

Individuality of experience and method is nowhere more pronounced than among expert mechanics responsible for the production and operation of press tools. There are usually several ways to solve a given problem in die construction, and the character of the tool layout for a difficult piece of work will differ in accordance with the experience of the men who have the matter in hand.

One method of attacking the problem represented by Fig. 238 is as follows: The flanged shell here shown is made in seven operations, one blanking, four drawing, one trimming, and a final forming operation to turn up the edge on the flange. The material is 0.035-in. drawing steel

and the shell is finished without any annealing. The blanks are made on a rotary shearing machine. They are then run through an ordinary "push through" type of drawing die, making a straight shell 5.75 in. diameter, 3 in. long.

For the second operation the same type of die is used but it has an inside blank holder to prevent the stock from wrinkling; and instead of

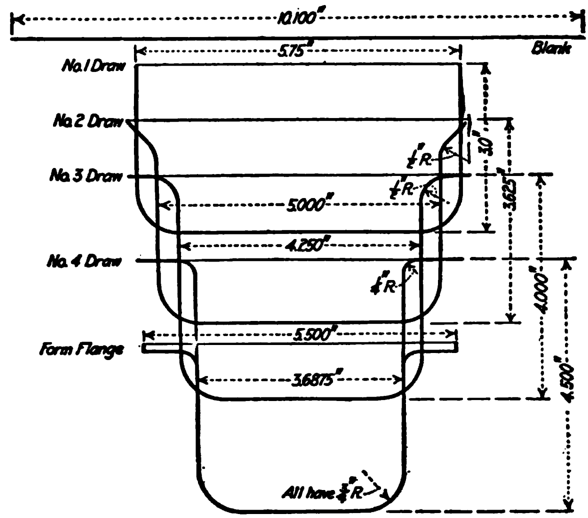


FIG. 238. — Drawing a flanged shell

pushing the shell through, it is drawn just far enough to leave a flange the size of the radius on the drawing edge of the die. This is the starting of the flange. The trimming operation follows in order to make the flange round. This was found necessary in order to obtain the required uniformity of pressure in the next drawing operation. The trimming is done with press tools, the punch being the lower member and the die the upper. The piece is located centrally on the punch by means of a pilot the size of the inside diameter of the shell.

The third drawing operation reduces the shell from 5 in. to 4.250 in. in diameter. The die is of the same form except that it has a cast iron stripper plate to the underside of which is fastened a tool steel ring that acts as a pressure plate. When the descending punch comes in contact with the stripper, it flattens out the flange on the face of the die as the punch completes the down stroke. The radius joining the flange and the body of the shell is now finish size. It required some experimenting to determine the correct time for the pressure plate to come into contact with the flange as the shell was being drawn, in order to exert enough pressure on the flange to keep it from wrinkling, yet not enough to cause it to roll over.

The Fourth Draw

The fourth drawing operation reduces the shell from 4.259 to 3.6875 in. in diameter. In this draw it seems to require sufficient pressure to cause the flange to roll in order to prevent it from developing wrinkles. Then as the flange is flattened at the bottom of the stroke there is a circular crease on the flange due to the action of the metal in being bent beyond a horizontal plane and straightened out again.

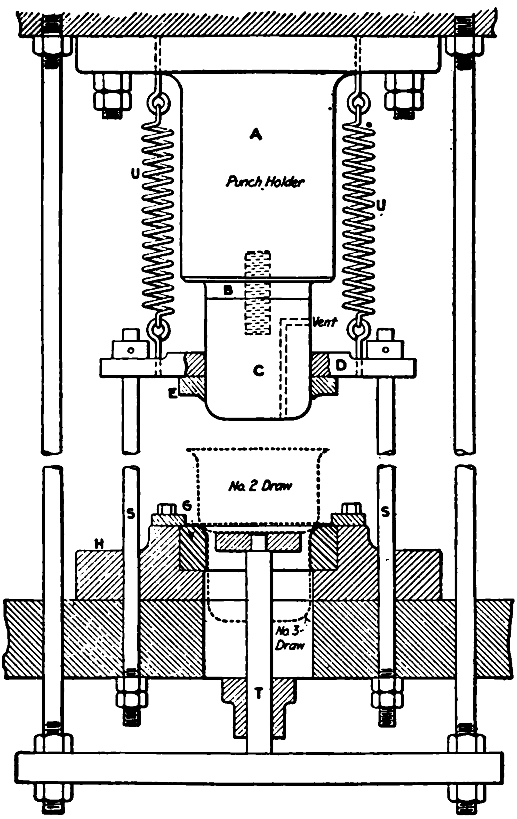


Fig. 239. — Arrangement of the dies for drawing shells shown in Fig. 238

Owing to the flange not being strong enough to stand the stress of stripping, it has been found impracticable under existing circumstances to turn up the edge on the flange in the finish operation. It is therefore necessary to make a separate operation of this, the final one in the development of the piece.

Referring to Fig. 239, *A* is a cast iron punch holder bolted to the ram of a toggle press with 13 in. stroke; *B* is a jacking ring and *C* the punch. At *D* is the stripper plate and *E* is a tool steel pressure plate, the radius on which is made to conform to that on the dies so as to iron out the metal on the flange. A positive knock out *T* is operated by side rods screwed into the ram of the press. At *G* is the die and at *H* the die shoe, which is bolted to the bed of the press. The duty of the two springs *U* is to keep the stripper *D* up on the punch and out of the way of the operator. The two rods *S* on the side serve as guide rods. They also hold the stripper plate *D* in place as the punch ascends, thus pulling the shell from the punch.

By trying out various diameters for the punches, it was found that best results were obtained when the diameter of the punch was from 0.010 to 0.012 in. smaller than the size determined by subtracting the double

thickness of the stock from the inside diameter of the die. The lubricant used was a compound to which was added about 20 per cent of lard oil and a small quantity of sulphur.

An Alternative Method

Another method which has been suggested for handling this shell drawing undertaking is as follows; it being believed that the shell could be blanked and drawn in three, possibly two operations. This method refers to dies for a double acting press, and Fig. 240 shows the type of die used for blanking and cupping. The blanking punch acts as a flange holder for holding the stock when drawing. The head on the drawing pad or die irons out all wrinkles that tend to form in the stock. The cup does not have to be drawn entirely through the die, but can be left with a flange and can be about the size of the second draw in Fig. 238.

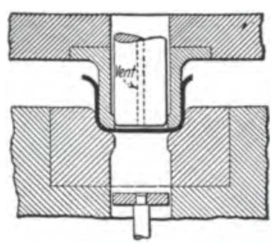


Fig. 240

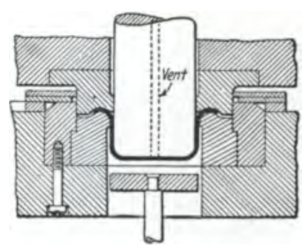


Fig. 241

Figs. 240–241. — Drawing steel shells

The blanking die must have shear ground on it, and the pressure exerted by the flange holder must be regulated to keep out all wrinkles and not thin the stock down too much. The head must have a large radius, so that the stock will not be broken and pulled in. About $\frac{3}{4}$ or $\frac{7}{8}$ in. is recommended for the size cup here shown. The drawing punch must be regulated to draw the right depth. These points can be determined by trial.

The type of die used for the drawing operations is shown by Fig. 241. This is also a double acting die. The die block is belled out to take the cup from the preceding die and has a large radius on the edge of the drawing portion of the die. A flange holder comes down inside the shell and holds the stock so no wrinkles can form, while the ram draws the cup as before to the proper depth.

After the shell has been reduced to the proper diameter, the flange should be flattened out on a single acting press and then trimmed. All dies should have guide studs or posts to aid in setting up and keeping them in line. If one stud is made larger than the other, the die and punch will not turn in relation to each other but will go together the same way each time.

The "Pinch Off" Type of Punch and Die

The principle of the draw and "pinch off" punch and die is used extensively in making jewelry settings and similar parts but is little known outside of factories specializing on this line of operations. The following description relates to a punch and die of this kind for making the box cover shown in Fig. 242. The stock is 0.014-in. low brass, dead soft, and the press is a single action machine run at 150 revolutions per minute.

The tools are shown in Fig. 243. The one feature to be emphasized is the fact that with these tools properly made, and regardless of a slight variation in the thickness of the stock, the cups or shells will always be of uniform height if the trimming punch is kept sharp. In the engraving, *A* is the die; *B* is the stripper which is held in place by cap screws *C*. It will be noticed that the drawing edge *D* of the die is well rounded. The exact amount for this work can be determined only by trial, although a man accustomed to these dies can almost always get the radius right at the first attempt. There is one important thing about this radius, that is it should not run into the straight part of the die *A* at a tangent but should run out as shown in the section at *K*, leaving an abrupt shoulder, as at *L*. This assists the pinch off punch to trim the cup evenly. In making dies for shallow settings it is only necessary to break the edge with an oil stone. Another important point is that the die should be ground absolutely parallel without any clearance and the stripping edge *E* of the die must be sharp in order to strip the cup from the drawing punch *F*.

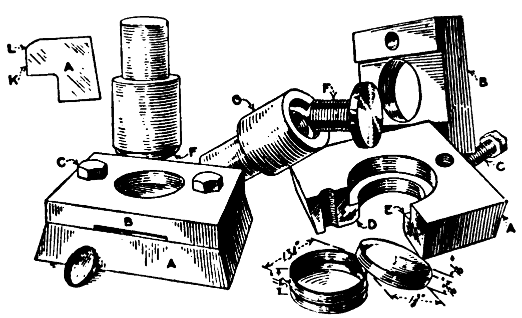


Fig. 243 Fig. 244 Fig. 242

Figs. 242–244. — Application of "pinch off" dies

The pinch off punch *G* is left large for grinding, and is drilled and tapped for a standard thread. The end of the punch is bored as shown. This is to permit regrinding on the face to sharpen and also to act as a means of keeping the drawing punch *F* concentric with the blanking punch. This latter feature is not usual in the practice of jewelry tool makers, who generally make the punch in one piece. In this case it is necessary when resharpening, to anneal the punch, true it up carefully in the lathe, turn back the pinch off shoulder as well as the draw punch to correct height and shape, and reharden, with the possibility of the punch going out of round. Still, this method is practical when the setting is too small to permit of the

use of the loose draw punch or where so few pieces are wanted that it would not pay to go to the expense of making the improved type of punch.

It will be found necessary to shear the stock somewhat wider than in general practice for plain blanking, and this amount can be determined only by trial. The stripper should be milled with little more than enough room for the stock to pass. This will hold the stock flat and prevent wrinkling, to some extent. With the feed rolls tight and the dies made right, this will be found a very cheap and satisfactory way of making shallow shells.

Other Applications of the Pinch Off Principle

This principle of draw and pinch off tools can be applied advantageously to other work. Consider for the moment Fig. 244, which is the powder box for which the cover, Fig. 242, is made. This box is finished $\frac{1}{32}$ in. deep and crowned on the bottom the same as the cover. On a double acting cam actuated press, the box is first drawn about $\frac{1}{32}$ in. larger in diameter than finish size. Then it is redrawn and pinched off to the proper height. A very satisfactory result is obtained and no further trimming is necessary if the punch is kept sharp.

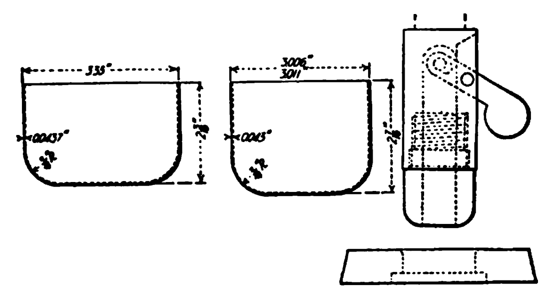


Fig. 245 Fig. 246 Fig. 247

Figs. 245–247.—Application of "knock off"

This type of punch and die can very often be used to advantage in drawing and trimming steel shells for various purposes. In Fig. 245 is shown a cup made of 0.0437 sheet steel, drawn upon a cam actuated cut-and-draw press and then redrawn to the dimensions given. After annealing it had been the practice to turn or face off in a drilling machine, the cup being held in special jaws while the cutting tool was fastened in the spindle. The cup was then put through a final draw and again sent to the drilling machine to be faced off to correct height, as shown at Fig. 246. As may be supposed, there were many rejections due to the facing off of too much material or to rough edges. In the latter case it was necessary to send the pieces to the polishing room to be ground, all of which tended to increase the cost of production.

To avoid further trouble of this character, a punch was made like the one in Fig. 243. The results were very satisfactory so far as the finished cups were concerned. While the draw punch was new and smooth, the work stripped off without any trouble but as soon as the punch became roughened a little the shells began to stick. So a special stripper or knock off was applied as in Fig. 247.

This consists of a central plunger which is connected to the arm seen projecting from the side of the punch. The end of this arm strikes the top of the die as the punch descends just after the trimmed cup has passed through the drawing die and is free to be stripped off of the punch. As the punch is permitted to continue on through the die for a short distance the cup is started or forced off for about 1 in. and as the punch is withdrawn, is stripped clear off by the shear edge of the draw die.

This device operates with entire satisfaction and is the means of saving two facing operations in the drill press with the usual losses.

Making a Funnel Shaped Shell

Thus far the dies illustrated in this chapter have been for producing cylindrical shells and similar articles with straight walls; but such objects form only a part of the work for which drawing dies are regularly used. They are quite as applicable to the making of conical shaped articles,

Fig. 248. — Tools for a conical shell

square and rectangular boxes and shells, and irregular parts of too great a variety to even designate by title. Frequently the drawing process is utilized for one or more steps in a sequence involving the application of forming and bending dies, trimming tools, and other press appliances of like nature, each doing its part of the work in advancing the article toward completion.

Drawing dies are frequently used in gangs for multiple production. They are also arranged on the progressive plan with other tools which are required for performing a preceding or a subsequent operation. In the form of combination dies they are used in almost endless variety.

The tools in Figs. 248 and 249 are a set for making the cone shaped or funnel formed article shown in detail in Fig. 250. This is a piece used in a coin register and it is made from 0.032 in. steel. It is three inches diameter at the large end and at the small end there is a $\frac{25}{32}$ in. nose drawn up to a height of $\frac{1}{8}$ in.

The work starts with the production of a blank in the dies, shown in Fig. 248, which cut out a disk 3¼ in. diameter. Then the work goes into the dies in Fig. 249 where the flat blank is cupped or drawn up to the approximate size wanted but with the smaller end rounded to the curve indicated at *A*, Fig. 250. This end is then brought up to the form *B* and

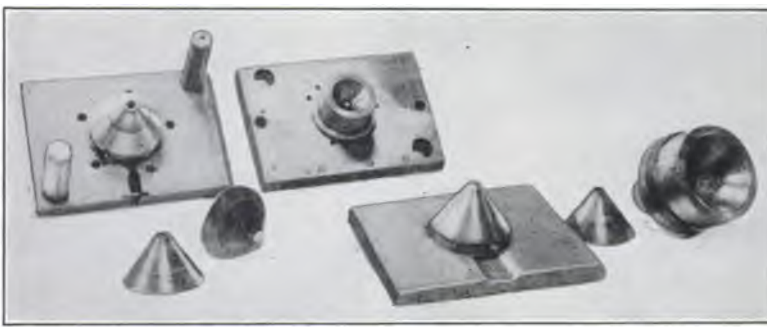


Fig. 249. — Tools for a cone-shaped article

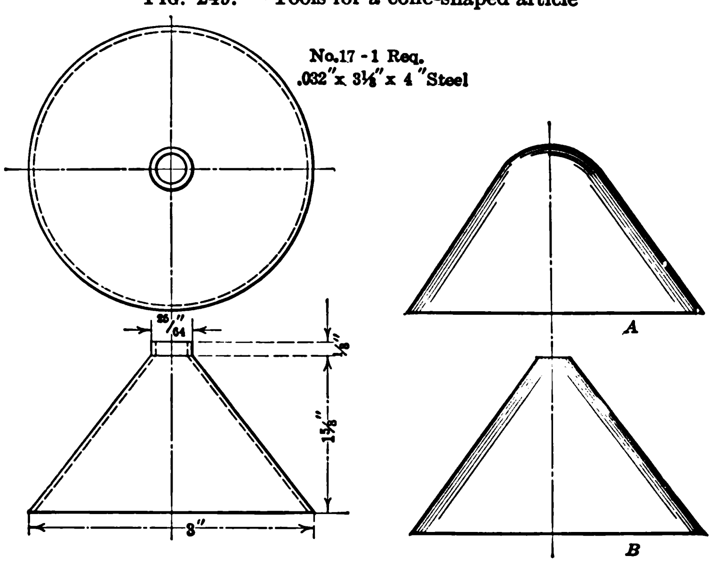


Fig. 250. — Detail of cone shell

the hole pierced in the point by the tools at the right in Fig. 249, which are adapted to operate on the top half only of the work. Then the finish tools at the left in this photograph set the whole cone up firmly to the shape of the conical lower die and open the hole and finish the collar or nose on the end of the piece.

With the exception of the last set of dies all of the tools on this work are of the open type but the finishing dies are of the subpressed order or made with pillars for alinement in operation.

An Irregular Oil Can Spout

As an example of an irregular piece of drawing work the oil can spout in Fig. 251 is referred to here. This illustration represents the spout in various stages from start to finish. The tools are shown by Figs. 252 to 256 inclusive.

The drawn object is made in nine operations and two anneals. There are five draw, one stamping, and three trimming operations. The metal is brass 0.020 in. thick, the blank being 4.5 × 3.250 in. By placing the set edges *A*, Fig. 252, at 70 degrees to the center line *B–C*, a strip 4.25 in. was used as stock.

The first operation is accomplished on a small cam drawing press. Coming from this the diameter of the shell is 1.75 in. and the depth $1\frac{1}{2}$ in. The production on this operation is 15,000 per day. It has been found that there is an advantage in making the drawing die of a separate piece of steel from the cutting die as shown in Fig. 252. When the drawing die becomes worn and has to be reground, this can be attended to by taking it apart and grinding the drawing and the cutting dies separately.

Fig. 251. — Steps in making an oil can spout

The second drawing operation is performed with a single acting reducing die, Fig. 253, the shell being reduced to 1.5 in. in diameter for 1 in. of its depth. In this operation a ratchet dial feed is used and the production is 25,000 per day.

The third drawing operation is made possible by the reducing die, Fig. 254, having the slide *A* placed on the side where the spout is to be formed. This slide has tension on it caused by springs *B*. As the punch *C* descends the lip *D* presses against the metal left to form the spout which pushes the slide *A*. This slide acting upon the principle of a jumper ring in a combination drawing die, keeps the metal smooth in the spout while it is being formed to shape. In this operation a ratchet dial feed is used and the production is 25,000 per day.

The fourth operation is done in a single acting reducing die like Fig. 253. The shell is here reduced to 1.25 in. in diameter for 0.5 in. of its length. The same type of feed is employed as for the previous operation and the same rate of production is obtained.

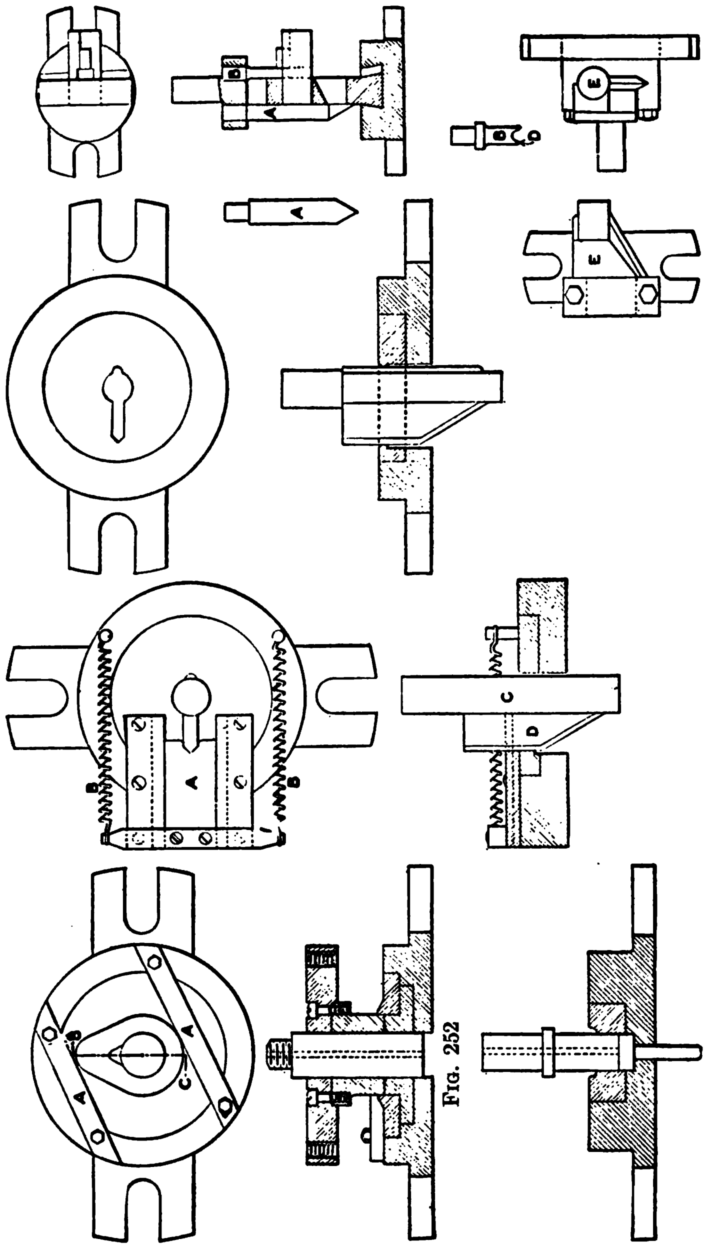


FIG. 252

FIG. 253

FIG. 254

FIG. 255

FIG. 256

FIGS. 252–256. — Details of drawing and trimming dies for an oil can spout

The fifth operation is performed with the reducing die, Fig. 255. The cylinder of the shell is reduced to 1.25 in. diameter. Feed and production are as before. The sixth operation is performed in a stamping die set in the crank press. Here again the same ratchet feed is used and the same rate of 25,000 pieces per day is obtained.

The trimming of the shell is done in three operations: First the nose and air vent are trimmed in one operation by the punches *A* and *B*, Fig. 256, the punch *A* being made with a V-shaped cutting edge to fit the spout, and the punch *B* with a cutting edge to fit the air vent of the shell. In the second trimming operation one side is trimmed in the die *E*, Fig. 256. The third trimming operation is performed in a die similarly made, but the reverse of die *E*.

Foot presses are used in all of the trimming operations and a production of 10,000 a day is secured with each operation. Soap water is the lubricant used on all of the drawing operations.

Peculiarities of Square Drawing Dies

Reference may be briefly made here to some of the special features in the construction of drawing dies for square and rectangular work. Improper tool designing for boxes of these forms will more seriously affect the product than in the case of plain cups and shells, and the following suggestions may be of service to those who now and then have work of this nature to look after.

Difficulty is frequently encountered in drawing rectangular shapes even though the tools may be to all appearances excellent examples of that class of die work, due principally to the fact that the radii of the corners and edges are not given due consideration. These radii are of the greatest importance when designing such tools and should be made as large as the shape to be drawn will permit. The drawing at the sides of the work is similar to a bending operation and the greatest stress upon material and tools occurs at the corners of the die. Should a box be required in which a corner radius of $\frac{3}{4}$ in. is permissible it is unnecessary to make it smaller.

The quality of metal used should receive due consideration, and in case of failure a set of dies should not be too hastily condemned or the operation pronounced impracticable when it may be the material that is at fault.

The radius of the drawing edge of the die should be uniform and smooth, the corners very hard and the top surface entirely free from grinding marks. Slightly more than the required amount of material thickness should be allowed for at the corners, as this reduces the amount of pressure and consequent wear on the die which will occur principally at these points. As stated, the radius of the drawing edge should be as large as possible, but if material is released from under the pressure pad or blank holder too rapidly, wrinkling will take place, probably resulting in fracture of the material or

in jagged corners. For thick stock this radius can be quite large, but for thin stock it should be small. A good rule is to make the radius about six or eight times the thickness of the material used.

When it is not practical to draw a box in one operation the corner radius of the first draw should be approximately four times the required radius of the finished shell. In order to illustrate more clearly the right and wrong method of design, the corner radius of first and second operation dies is shown in Fig. 257. At *A* the radii for both operations are drawn from the same center. At *B* is shown the proper method. Note that the radius is described from a different center for each die.

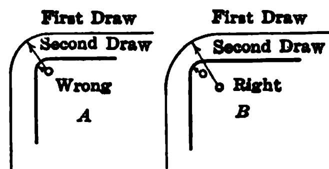


FIG. 257

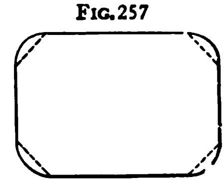


FIG. 258

FIGS. 257–258. — Corners in square and rectangular dies

When a die maker not familiar with this class of work is called upon to determine the required blank size he not infrequently makes the trial blank as shown by full lines in Fig. 258, but after repeated trials he will reach the conclusion that the shape as shown by dotted lines is more nearly correct. A method of eliminating some of these trial blanks and arriving at once at the proper shape and size for work of this character will be found in another section of this book (p. 369) relating directly to the finding of blank sizes and to lay out operations in general.

DRAWING WORK INSIDE OUT

It is occasionally desirable to redraw work by turning it inside out, thus securing a greater degree of elongation at each operation. An example of a shell made in this manner is illustrated herewith with the dies for performing the series of operations required in making this shell, which finishes to a length of $6\frac{3}{4}$ in. and an inside diameter of $1\frac{13}{16}$ in., the wall being 0.028 in. thick. The material is Britannia white metal.

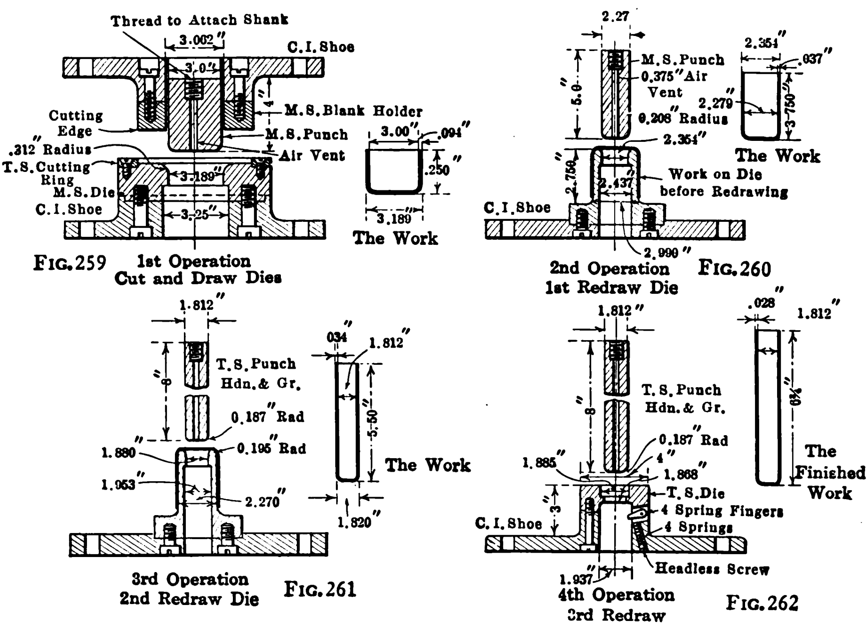
The work is performed in four dies and comes out of the operations with a highly polished surface. The dies are shown in Figs. 259 to 262 inclusive with the progress of the shell indicated in each view by a detail sketch.

These sketches of the dies are practically self-explanatory but a brief outline of the operations may be of value. The cutting and drawing dies, Fig. 259, are used in a double action press with a blank $6\frac{1}{4}$ in. square and 0.094 in. thick. These first dies give a cup 3 in. in diameter by $2\frac{1}{2}$ in. higb but do not thin down the walls at all as the difference between the punch diameter and the die is made just twice the thickness of the blank.

During some earlier experiments with this work good results were secured until the final operations were reached; then the percentage of broken pieces would be anywhere between 50 and 75 per cent, sometimes more. That was with the ordinary method of redrawing. Then it was decided to try to turn the preceding cup wrong side out, so the second and third operation redrawing dies were made on that principle and thereafter there was practically no trouble.

The second, third, and fourth dies can be used in any ordinary single action press, provided the stroke is long enough.

The dies, Fig. 260, for the second operation bring the walls of the tube down to 0.037 in. thick and lengthen it to 3¾ in. The cup after passing



Figs. 259–262. — Drawing tubes inside out

through the first operation dies is inverted over the die for the second operation. This die is made 0.010 in. smaller on the outside than the inside diameter of the work to facilitate matters when feeding, as the press can be run continuously, the work dropping down through the center of the die into a box.

Third and Fourth Draws

The third operation, Fig. 261, consists of the same operation as in the second, only the die is made to draw the work down to the required inside diameter with walls 0.034 in. thick, giving a shell 5½ in. long.

The punch for the third operation is used on the fourth or final draw,

and the die is made as in Fig. 262. This completes the work, making a shell or tube $1\frac{3}{8}$ in. diameter, $6\frac{3}{4}$ in. long, and 0.028 in. thick through the walls, with a high polish on the outside. Of course the die has to be highly polished to give these results, and the punch is hardened, ground, and lapped as the work after passing through this last die holds tightly to the punch.

The dies for the first, second, and third operations are made of machine steel and left soft, but polished, and the cutting ring for the first operation is of tool steel but is not hardened.

The work automatically strips itself from the punches in the first three operations, as there is a little outward spring to the top walls of the work. In the last-operation dies, four spring fingers are placed around the die, to just let the punch through without touching. When the work is on the punch, these fingers spring downward and over the top, thus stripping it off the punch on the upward stroke.

The only lubricant used on these four operations is a mixture of soft soap, soda, lard oil, and water, all boiled together and left to cool before using.

The uneven ends of the work are not trued up between operations, as this is unnecessary and would only waste stock and shorten the final tube. The work is not annealed or touched between operations.

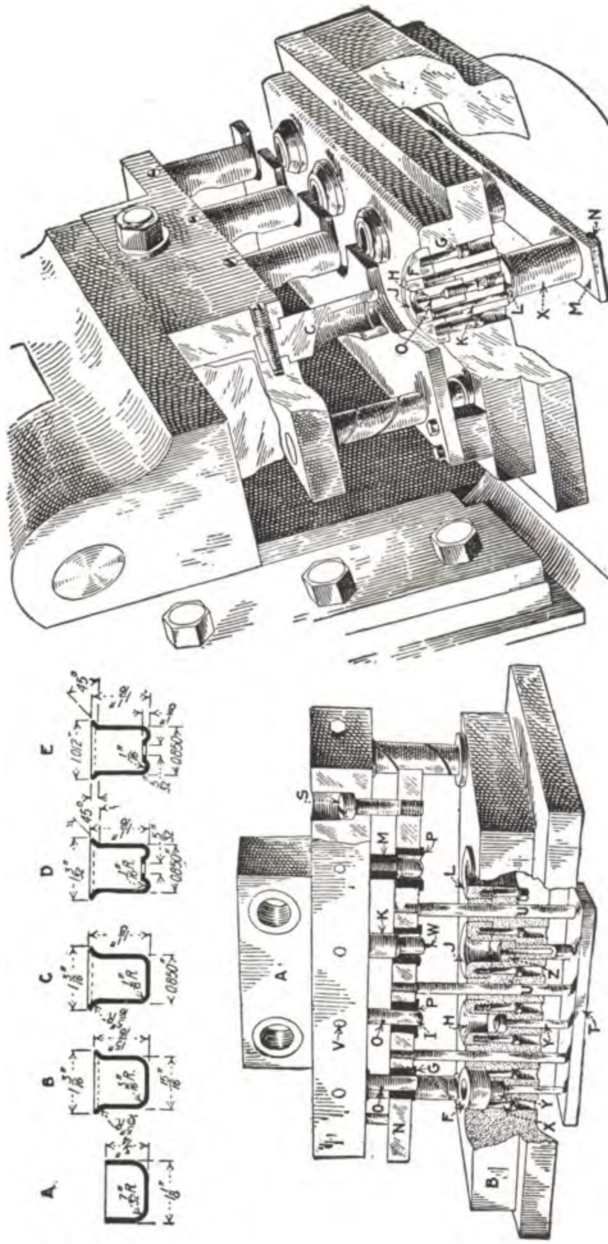
Gang Drawing Dies for Steel Thimbles

As stated before, drawing dies are frequently arranged in gangs for convenience of operation and for high production. An example is seen in the accompanying outfit for manufacturing the steel thimble shown in Fig. 263 herewith.

This thimble is made of No. 14 gage cold rolled stock. It must be held close to the required dimensions and is made in five operations without annealing. The walls must be held to original thickness. By making the thimble in five operations the reduction is gradual and the stock is less strained, thus preventing the stretch that would otherwise occur.

Subpress dies, or dies with guide pillars, are used to facilitate the die setting, and fewer presses are necessary to start the work. In this way the presses can be set up and the finished article turned out in a very short time as compared with the usual method of running a single operation on a press. The drawing dies are operated in two small presses set close together. The blanking and cupping operation is performed in an inclined press.

The punch C, Fig. 264, serves a double purpose. As it descends it cuts the blank, which is held between its face and the pressure plate J. As it descends further, the blank is forced by the punch H through the central hole in C, thus forming the cup. The pressure on the plate J is obtained from the pins K and the rubber bumper X. The required



FIGS. 263–265. — Gang drawing dies

regulation of pressure on the plate J is obtained in the usual way by the stud L and the nut N. The blanking die F is held by screws G. The cup is carried up into the cavity in the punch C and as this die is used on an inclined press, the cups roll out of the opening at the back and into a receptacle, being forced out by the succeeding cups as they are formed. At no time are there more than two cups in the cavity.

The lower punch is vented at O so that the cups will strip readily. The production on this operation is 3000 pieces per hour.

Following Operations

The second, third, fourth, and fifth operations are now put through the die shown in Fig. 265, whereby the operator transfers the operations in proper rotation from one die to another, keeping all dies supplied. The capacity of this die is 1000 pieces per hour.

In Fig. 265 is shown the front view of the gang dies for the four final operations. The punch holder A and the die holder B are kept in proper alinement with each other by guide pins.

The shell B (Fig. 263) is drawn in the second operation die F by the punch G. This punch has an air hole to allow easy stripping. The shell C (Fig. 263) is drawn in the third operation die H by the punch I. This punch has an air hole at O. The shell D is drawn in the fourth operation die J by the punch K, a 45-degree angle flange being bulged in the bottom and a $\frac{5}{32}$ in. hole punched. The shell E is trimmed on the flange in the fifth operation die L by the punch M.

The stripper N is held in place by the screws SS, which are long enough to give the stripper the proper movement to release the shells from the punches with the aid of the lower knockout plate T. This stripper is fitted with carbon steel bushings screwed into place. The knock out plate T also releases any shells from the dies by giving the knock out pins Y and Z the proper movement. The stripper bolts U are adjusted in relation to the stroke of the press.

The punches G, I, K, and M are held in position by tapered pins V. The punch K has a perforating punch W inserted to perforate the bottom of the shell and must be adjusted to suit the thickness of the metal in order that it may not go through too far before the forming of the bottom takes place. The dies F, H, J, and L are held in position by the screws X. The knockout pin Z in addition to acting as such also serves as a perforating die for the fourth operation.

Progressive Dies for an Automobile Hub

The manufacture of a pressed steel automobile hub as carried out by means of the following tools forms an interesting illustration of the application (among other types) of the progressive arrangement of dies for certain kinds of drawing operations. This steel hub, as shown in Fig. 266, is drawn from a cold rolled blank $13\frac{1}{8}$ in. diameter and $\frac{1}{8}$ in. thick. It is

finished in 10 operations. Several of the dies are of the tandem order which increases production and decreases the number of presses used.

The tandem drawing dies are set upon double acting presses. They can be operated by one operator but two are required when the greatest possible output is desired. When two operators are engaged on one press, an electric device with four pushbuttons is put in action, whereby both operators must touch the four buttons in unison before the press can be

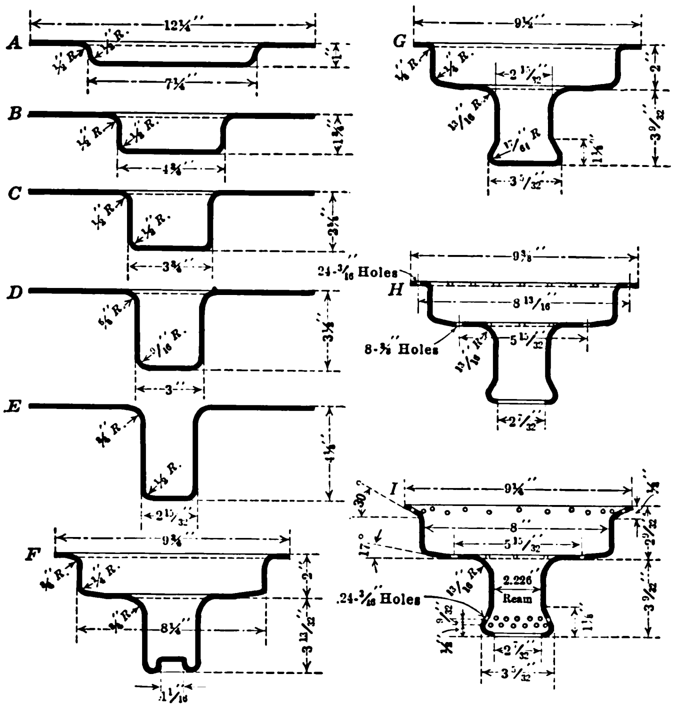


FIG. 266. — Successive steps in drawing a pressed steel hub

brought into action by a foot treadle controlled by one of the operators. This arrangement protects both operators from being injured in any way.

As mentioned elsewhere, it is customary in most plants making pressed steel articles to draw shells with dies that have only enough clearance between punch and die for the thickness of the stock, the punch being made twice the thickness of the stock smaller than the die diameter. This is not always practicable where heavy material is drawn, where strength is more desirable and uniformity of wall thickness of less importance.

The first four operations on this hub are handled in drawing dies that are $\frac{1}{32}$ in. large. The dies work easily and keep free from scratches. This saves much time usually taken to polish the radius. The stampings release with less friction when made under these conditions and the stock being

subjected to lower stress will admit of passing through more operations without annealing. The walls of the shell are apt to thicken up and this is desirable where strength is required. Necessarily, the production from dies operated under these conditions is greater.

The first two operations shown at *A* and *B*, Fig. 266, are the blanking and drawing on the dies in Fig. 267, operations 1 and 2. The stamping *A* when blanked and drawn is transferred from the first operation to the second operation die, which reduces its diameter to 4¾ in. and turns the stamping completely inside out. Whenever it is possible to apply this

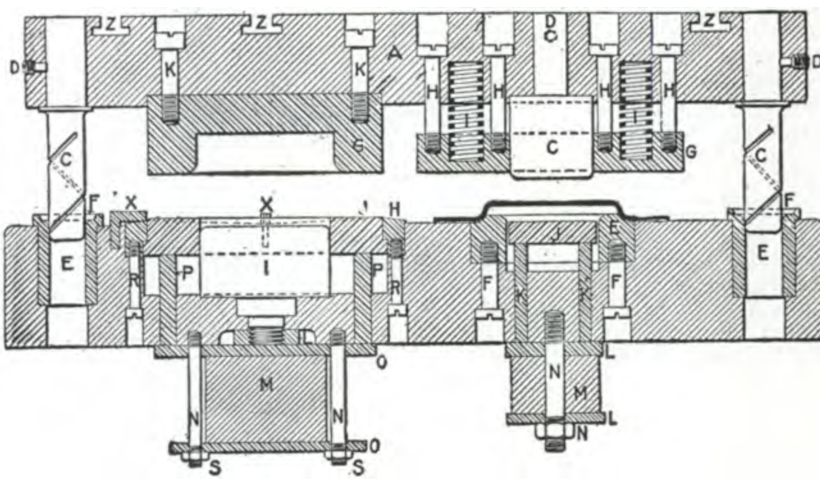


Fig. 267. — First and second operations

method it should be adopted, as with it a greater reduction in diameter is effected.

The tandem dies in Fig. 267 are made of steel sections set in cast iron plates *A* and *B*. To facilitate setting up of the dies the guide pins *C* are added and held in position by the set screws *D*. The guide pins are made of hardened tool steel and are ground 0.002 in. smaller than the bronze bushings *E*. The bushings *E* have at *F* recesses that are filled with a mixture of machine oil and white lead to lubricate the guide pins *C*.

Referring to the first operation dies, the blanking punch *G* is held in place by the screws *K*. The blanking die *H* is held by screws *R*. Both punch and die are made of tool steel hardened. The punch *G* is hollow and allows the punch *I* to enter it as it descends. The blank from *H* and *G* is formed between *I* and *G* to the shape shown at *A*, Fig. 266. The punch *I* is held in place by the nut *L*. The pressure plate *J* is made of hardened tool steel. It prevents wrinkles in the work and at the same time acts as a knockout to raise the work out of the die and to a position where the operator can quickly transfer it to the second operation die.

The pressure on J is controlled by the rubber bumper M. Adjustments of the pressure are made by tightening the nuts S against the plates O. Care must be exercised in adjusting this pressure pad as too much pressure on it may strain the work on the radius and cause it to break when subjected to succeding operations.

The gages X are tool steel, hardened. The rear gage must be set to the edge of the die in order to allow the steel to part and open. This prevents the steel from holding to the punch, obviating the necessity for a stripper plate on the die.

The Second Operation Dies

The second operation dies operate in the same manner as those for the first operation. C is the punch, held in place by a taper pin D. The die E is secured by the screws F. Both punch and die are made of tool steel,

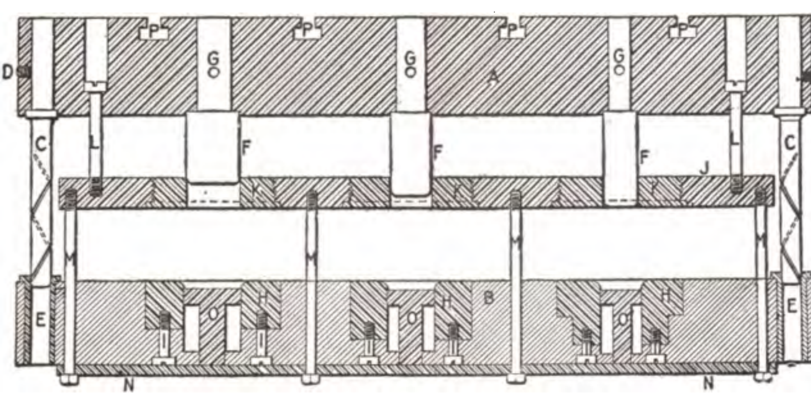


Fig. 268. — Third, fourth and fifth operations

hardened. The stripper G acts also as a pressure pad and is held in place by the screws H. It is given the proper pressure and ejecting action by the springs I. The knockout J, which discharges the stamping from the die is made of tool steel, hardened. It is actuated by the pins K and plates L when the rubber bumper M is properly adjusted by the bolt and nut N.

The shoe A has T-slots Z to fasten it to the ram of the press. The stampings CDE, Fig. 266, are reduced from $4\frac{3}{4}$ to $2\frac{15}{16}$ in. diameter in three operations. The work is drawn on tandem dies shown in Fig. 268. This die also is operated in a double crank press. The shoe or punch casting A is made of cast steel and the shoe B of cast iron set with steel dies and punches. These are guided by the pins C, held by set screws D, and ride with the necessary freedom in the bronze bushing G. The dies H are of tool steel, hardened; they are held in place by screws I.

The stripper plate J has hardened bushings K which act as pressure

pads to flatten the flanges of the work. The stripper is held by the bolts *M*, which carry the lower plate *N*. This lower plate is so adjusted that it gives the shoulder knockout *O* the proper travel to expel the stampings *CDE*, Fig. 266, when the ram is on its upward stroke. The T-slots *P* are for securing the punch to the ram of the press.

The Sixth Operation Dies

The stampings *E* are now annealed and pickled to remove all scale before they are put through the sixth operation dies, shown in Fig. 269. Here they are formed into a hub $8\frac{1}{4}$ in. in diameter and the bottom is indented. The indentation die is necessary to shorten the hub to fit the

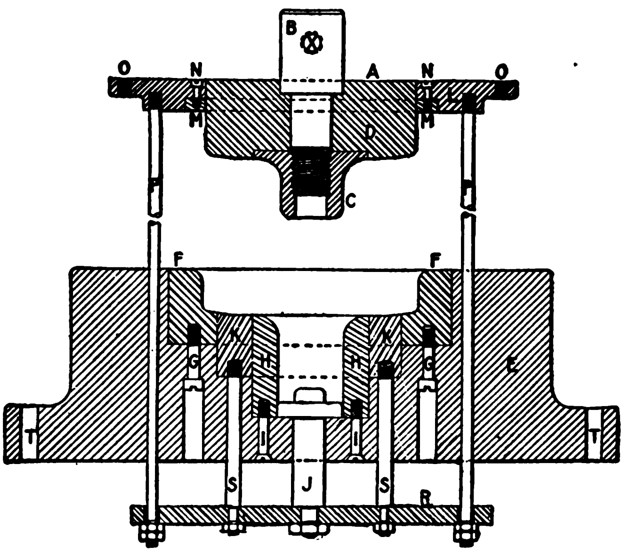


Fig. 269. — Sixth operation

succeeding die, as well as to supply the much needed stock that is necessary for bulging in a later operation.

At *A*, Fig. 269, is the punch, which is made of tool steel, hardened. The stud *B* has a hole *X* through the shank to secure it to the ram. It is threaded on the opposite end to hold together the sections *BCD*. The shoe *E* is of cast iron and serves to hold the dies that are made in sections. The forming die *F* is secured by screws *G* and is of tool steel, hardened. The bushing *H*, held by screws *I*, is also of hardened tool steel and serves to guide the hub in its downward course to indent the bottom with the tool steel hardened punch *J*. A tool steel hardened ring *K* acts as a knock out, should the hub stay in the die. The stripper *L*, which also serves to flatten the flange of the hub, is made of machine steel and has a hardened tool steel ring *M*, which is held in position by screws *N*.

The stripper *L*, which is free to slide on the punch *A*, must be held to the ram by bolts and given the proper sliding adjustment. The tapped holes *O* are provided for securing it to the press ram. The rods *P* are screwed to the stripper pad *L* and carry the knockout plate *R* underneath the die.

The knockout ring *K* is fastened to the plate *R* by the bolts *S* and when properly adjusted works as a unit in connection with the stud *J* to release the hub on its upward stroke. The holes *T* in the die serve as a means for bolting it to the press.

The Bulging Process

The hub *F*, Fig. 266, is now put through the oil bulging dies. This is the seventh operation and is shown in Fig. 270. The end is bulged out until it fills the cavity *Z* in the die, forming the necessary end. The

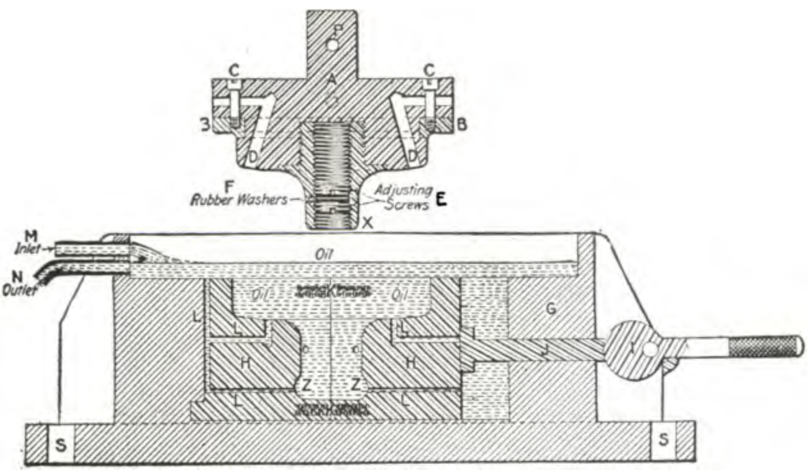


FIG. 270. — Seventh operation

flanges are also squared in this operation. The hub should be 0.010 in. small at *O* in the dies, so that the punch *X* when entering the hub will expand it to size. There being no escape for the oil because of the tight fit of the punch in the work, the hub will be bulged out until it fills the cavity *Z* in the die.

The punch *A* is made of machine steel with a hardened plate *B* held by the screws *C*. This plate serves to flatten the flanges on the hub. The holes *D* are drilled in the punch and serve to discharge the oil from the upper part of the hub. The point *X* is made of high speed steel and can be replaced quickly when, through wear, this becomes necessary. In addition to the ram adjustment the adjusting screws *E* and the rubber washer *F* must be set with care in order to regulate the amount of oil necessary for bulging. If the set screws *EE* are too high in the punch, the pressure in the bottom of the hub is decreased to such an extent that it will not fill

the cavity *Z*; and if the screws are too low in the punch, there is too much pressure, which might result in damage to either the press or the die or both.

The die shoe *G* is of cast iron and serves as a reservoir and die holder. The die *H* is made in halves and is opened by the cam *I* and a square sliding pin *J*, assisted by the springs *K*. Oil channels large enough to discharge the surplus oil are provided at *L* in the die as well as at *D* in the punch. The inlet and outlet pipes *M* and *N* must be so placed as to give at all times the proper depth of oil in the reservoir. These pipes are supplied with lard oil through properly adjusted automatic pumps. The punch is secured by a pin through the hole *P* in the shank. The holes *S* in the die serve to secure the die to the press.

Perforating Operations

The hub *G*, Fig. 266, having been finished on the bulging die, is now ready to be perforated in the eighth operation die, shown in Fig. 271.

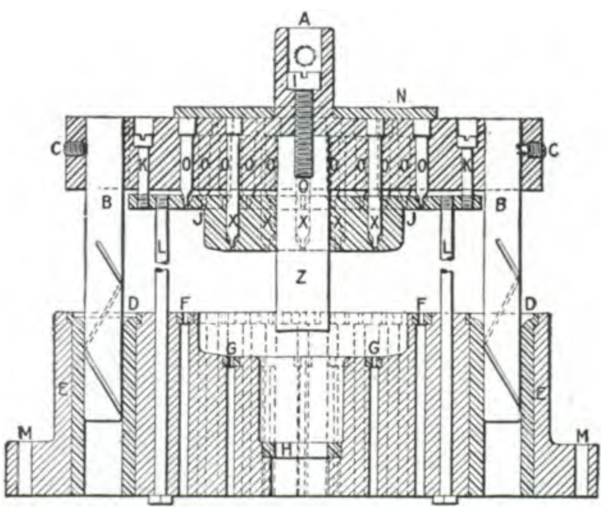


Fig. 271. — Eighth operation

The punch *A* is of cast steel, has twenty-four $\frac{3}{16}$-in. punches *O*, eight $\frac{3}{4}$-in. punches *X*, and one $2\frac{7}{32}$-in. punch *Z*.

The small punches *OX* are made of tool steel, hardened. They are driven into place and have shoulders backed by the hard plate *N*. The punch *A* has guide pins *B* secured by screws *C*. The guide pins work in bronze bushings *D* seated in the cast iron die plate *E*. The die plate *E* has 33 dies pressed into place. These correspond to the punches. The dies *F* and *G* are of tool steel and hardened.

The large bushing *H* is made of tool steel, hardened, slightly tapered,

and pressed in place. The small and large punches are staggered so as to use as little power and be as easy on the dies as possible. The large punch *Z* is made of tool steel, hardened and held in place by the screw *I*. The stripper *J* is made of machine steel and is held in place by the screws *K* that slide in the punch with enough freedom to allow the stripper to disengage the hub from the punches. The stripper bolts *L* must be adjusted to suit the stroke of the ram. The holes *M* are for bolts to secure the die to the press bed.

The hub *H*, Fig. 266, having been perforated, is now trimmed on the flange and beveled, which concludes the press work. This operation is performed on the ninth operation die shown in Fig. 272. The punch holder *A* is made of cast iron and has a stud and two T-slots *B* to secure it in the

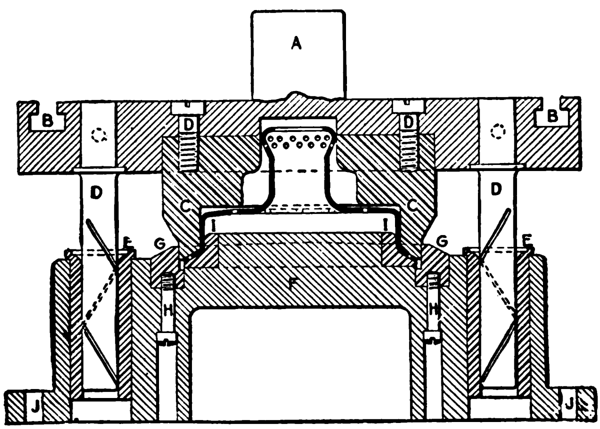


Fig. 272. — Ninth operation

ram. The holder *A* is counterbored to seat the hardened tool steel, hollow trimming and beveling punch *C* which is secured by screws *D*. The guide pins *D* slide in bronze bushings *E*. The die plate *F* is of cast iron and seats the tool steel trimming die *G*, which is held by screws *H*.

The ring *I* is of tool steel, hardened and pressed on *F*. It acts as a beveling die. The last operation consists in drilling the small spoke holes in the bulged end of the hub and is performed in the drill press with the aid of a jig.

Drawing Large Work of Aluminum

The half-tones, Figs. 273 to 276, illustrate the operation of a heavy toggle press in the drawing of aluminum ware with double acting dies. Details of the punches and dies are given in Fig. 277.

Referring to the press views, Fig. 273 shows the two slides at the top of their stroke, with a blank disk of aluminum on top of the die face. This blank has been prepared in a previous operation and here it is located

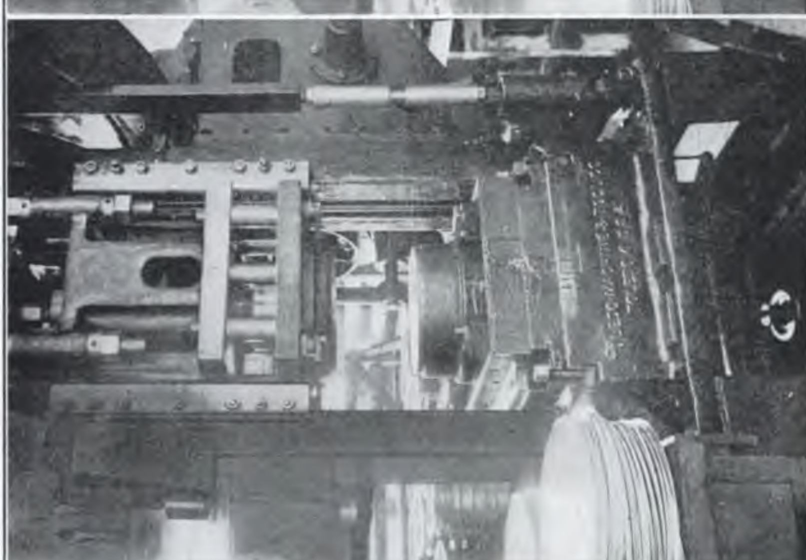


FIG. 273. — Drawing aluminum in toggle press

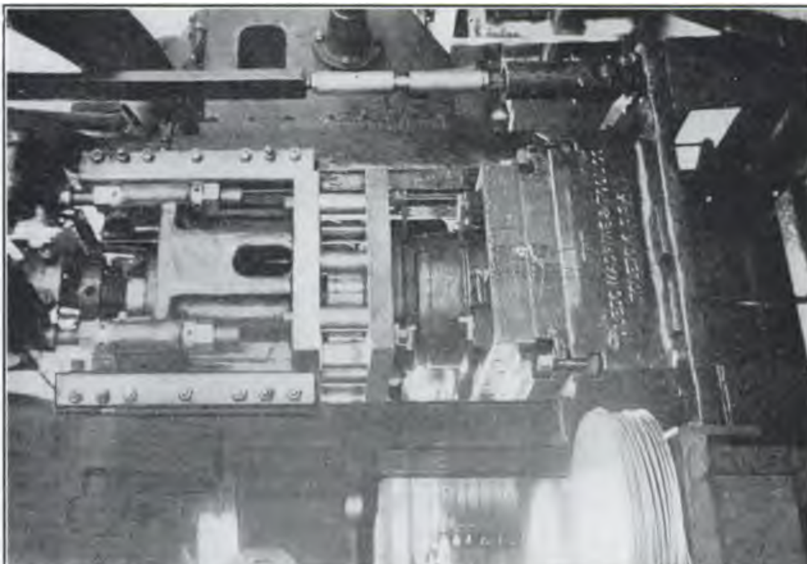


FIG. 274. — Punch holder and punch in operation

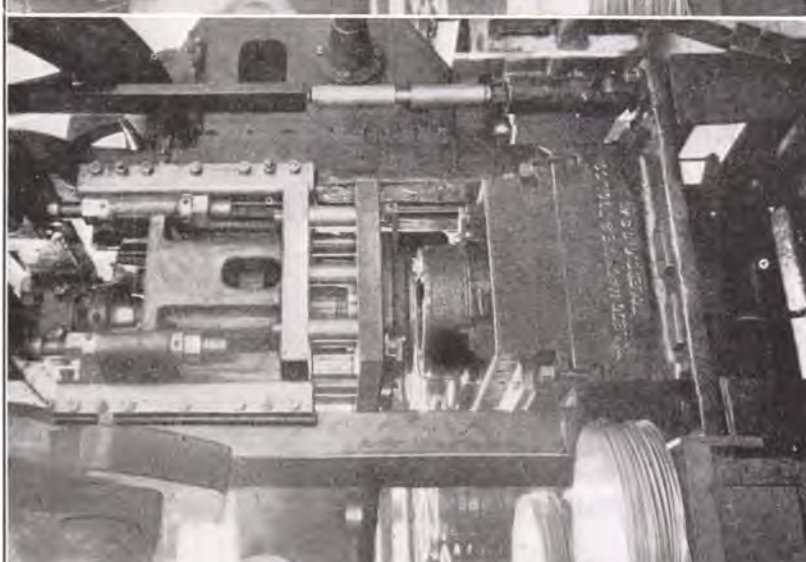


FIG. 275. — Double slides rising to clear punch

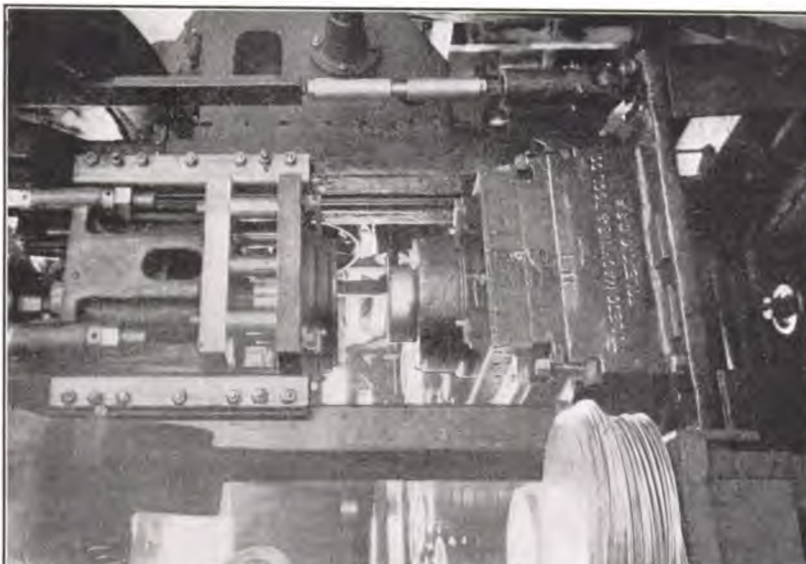
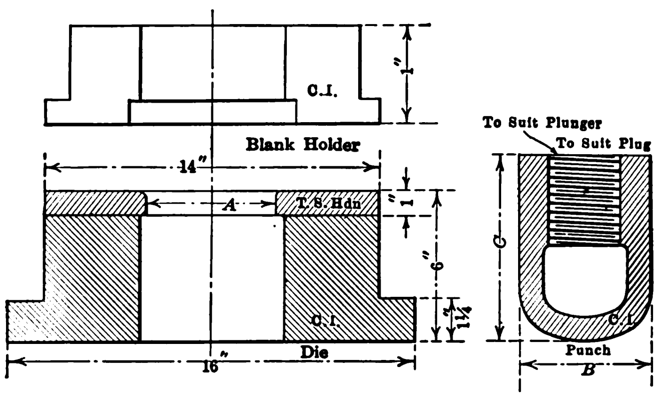


FIG. 276. — Work being ejected

against a couple of low stop pins in the face of the die near the rear edge. In some sizes the equipment is arranged for blanking and drawing in the first operation, as is so commonly done with shell work in general. But in this instance the outer slide of the press is fitted with a pressure plate or blank holder which is not provided with a cutting edge but instead is used under the double acting arrangement to apply the requisite pressure to the blank to prevent it from wrinkling while it is being carried down into the die.

In Fig. 274, the outer slide of the press is at the bottom of its travel and the pressure plate is shown holding the work under suitable pressure while



Dimensions of Tools

1st Op. Die	1st Op. Punch	
A = 8 7/16"	B = 8 5/16"	C = 6"
2nd Op. Die	2nd Op. Punch	
A = 6 9/16"	B = 6 7/16"	C = 10"
3rd Op. Die	3rd Op. Punch	
A = 5 5/16"	B = 5 3/16"	C = 15"

FIG. 277. — Tools for drawing aluminum ware

the punch is carried down by the inner slide or plunger. In Fig. 275 both outer slide and inner plunger are shown rising from the work, the punch of course being well cleared before the pressure plate or blank holder lifts, and in Fig. 276 the tools are both in their uppermost position and the work is being ejected from the die by the lower knock out, the arrangement of which is clearly shown in the different photographs.

The drawing, Fig. 277, gives the dimensions of the dies in the outfit and the sizes of the punches. The work is made from $\frac{1}{16}$-in. aluminum and is not reduced in thickness during the drawing process. The blank is 13½ in. diameter at the start and the first draw forms it into a shell 8$\frac{7}{16}$ in.

outside diameter by 3 in. deep. The second operation lengthens it to $5\frac{1}{4}$ in. with a diameter of $6\frac{1}{2}$ in. and the third draw produces an article $5\frac{3}{8}$ in. diameter by 6 in. deep.

The die proper is a hardened tool steel disk 1 in. thick which is screwed to the top of the die bolster. The radius on the drawing edge of the first operation die is $\frac{3}{8}$ in. or six times the thickness of the material drawn. The punches are hollow as indicated and are cast iron cored to the interior form shown. They are threaded at the upper end to suit the press plunger. Their lengths are given in the table under the detail sketches.

Cast Iron Dies

On some work of this character at different shops the aluminum is drawn in cast iron dies, that is without the steel die shown on top of the bolster. It has been observed in connection with such practice in certain

Fig. 278. — Shells drawn with cast iron punches and dies

places, that the cast iron die works satisfactorily so far as general results are concerned and it is the belief of some operators that the surface of the cast iron holds lubricant better and results in a better general finish for the surface of the object drawn. On the other hand, the cast iron is more quickly subject to surface wear and if the articles drawn have to be held closely to diameter this feature is an objection, particularly where large quantities of similar parts are produced.

With fairly limited runs, wear has been found negligible as observed over a reasonable length of time. Of course, from the nature of much of the material manufactured from aluminum in the direction of utensils and the like, it is obvious that no great degree of accuracy is essential (except where certain pieces must fit properly together) and consequently

any reasonable degree of wear on the die may be overlooked entirely so long as the work is drawn satisfactorily from a point of view of appearance.

In this connection it may be stated that cast iron punches and dies have been used successfully for drawing steel shells of moderate size and so far as records go they have stood up to the work as long as the run lasted.

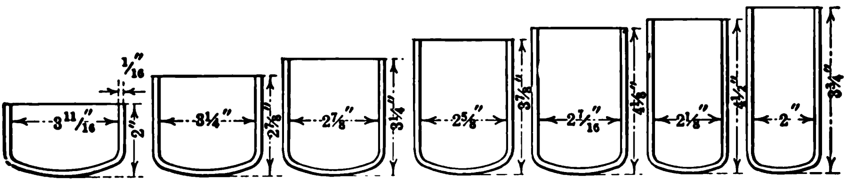


FIG. 279. — Seven operations on cold rolled steel shell drawn with cast iron punches and dies

Naturally they were not made in the first place for as extended a period of service as one would expect of a set of standard tool steel dies of the same proportions. But for a fairly large lot of shells on a special order they have given every satisfaction.

FIG. 280. — Large cast iron drawing and forming dies

The photograph, Fig. 278, illustrates the successive stages of a steel shell drawn up by seven pairs of cast iron punches and dies from a blank $\frac{1}{16}$ in. thick. The tools in the background are the cupping or first operation set, the drawing dies and punches all being of the same simple design. The modification in the shell as it progresses from cup to completed form is shown with over-all dimensions in Fig. 279.

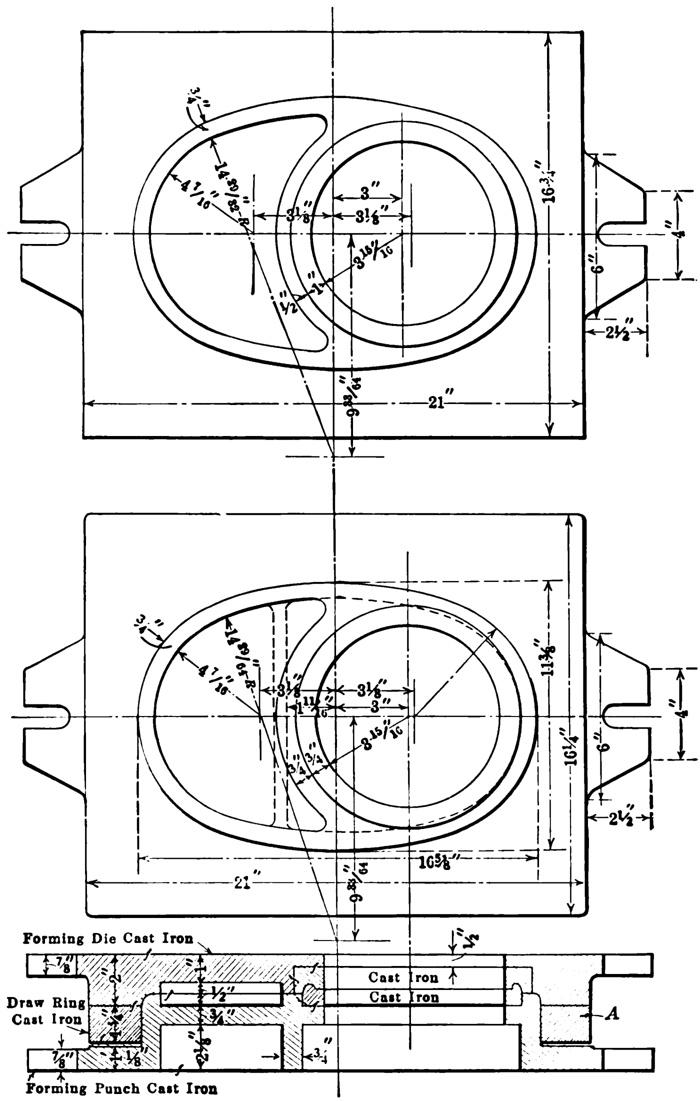


FIG. 281. — Tools for large metal cover

These shells all appear as smoothly drawn as if the work were done in the usual steel dies. There is no reduction in the thickness of the walls of the work as the drawing is carried along and all punches are smaller than die diameters by twice the thickness of the material.

Larger Sizes of Dies of Cast Iron

When we reach the larger sizes of work, such as sheet metal containers and covers of various kinds, there are numerous occasions upon which cast iron drawing tools are made use of. The photograph, Fig. 280, shows a few of a large number of such tools in the corner of a press room and details of two different sets are reproduced in the line drawings that immediately follow.

Thus, Fig. 281 is a shallow drawing and forming outfit for the thin sheet cover, Fig. 282, which is drawn up from $\frac{1}{32}$ in. black iron. The dimensions on the drawing show the length of the oval shaped piece to be

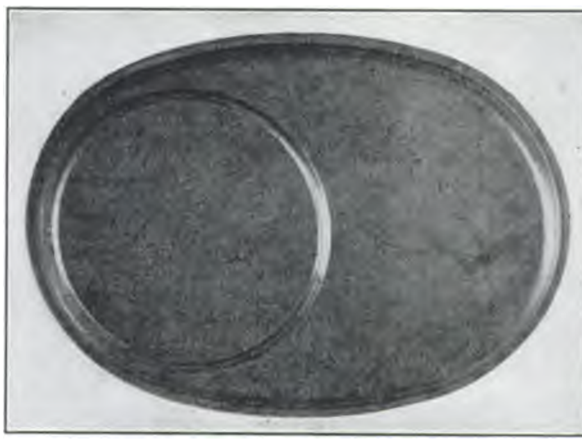


Fig. 282. — The work produced in the dies in Fig. 281

$16\frac{5}{8}$ in. The draw is very little in this instance, say $\frac{1}{2}$ in. or so for the edge with a forming depth for the circular portion of about $\frac{3}{8}$ in.

The cast iron draw ring *A*, which acts as a pressure ring for holding the stock against wrinkling, is controlled by a series of vertical pins that extend down through openings in the press bed and rest upon a spring plate secured beneath the press for use with all kinds of drawing dies of this character. This makes it unnecessary to apply a special pressure device with each die or type of die. The arrangement of the spring pressure plate will be understood from Fig. 283 which shows the press with a number of the pressure springs projecting below the bed.

Another set of dies made of cast iron and used on this form of press are illustrated at *A*, Fig. 284. These dies perform the operations of drawing, preparatory to the trimming and curling of a metal cover finishing 14 in. inside diameter. The same style of tools are also used for even larger work of similar character.

The metal drawn is No. 28 gage ($\frac{1}{64}$) black iron. The draw from the blank is $1\frac{9}{16}$ in. deep and a flange is left by drawing tools *A* for trimming and wiring in succeeding operations. In the drawing dies, the pressure ring (which is supported by the pins *B* extending down through the bed of the press to the spring plate beneath) is made of machine steel but the actual drawing members *D* and *E* are cast iron only.

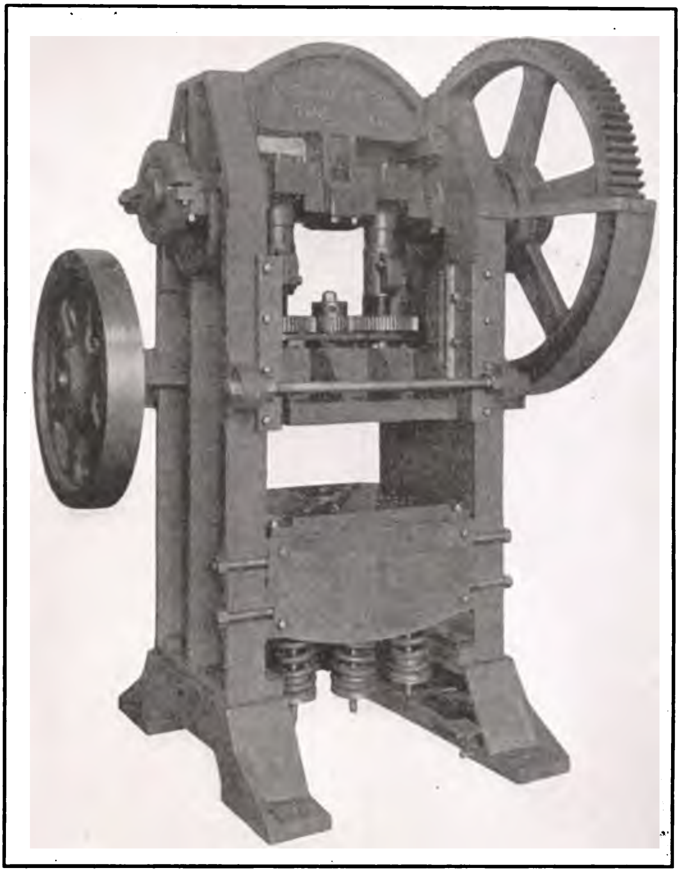


FIG. 283. — Press, showing spring plate attached under bed to operate pressure pins in dies

The steel drawing ring which is, of course, left soft, is recessed across its upper face to form a seat or retaining chamber for the blank. As the upper die descends, this drawing ring is forced down against the upward pressure of the spring plate under the press and has the effect of ironing out the metal and preventing the forming of a wrinkled surface on the work. Thus the full depth of $1\frac{9}{16}$ in. is drawn down over the lower die without difficulty.

Then the work is placed in the trimming dies *B*, Fig. 284, for the shearing off or trimming of the edge around the piece.

These trimming dies have tool steel cutting edges in the form of rings of about $1\frac{1}{4}$ in. section, which are made of tool steel, the lower one being hardened, the upper left soft. The former ring is pressed into its seat

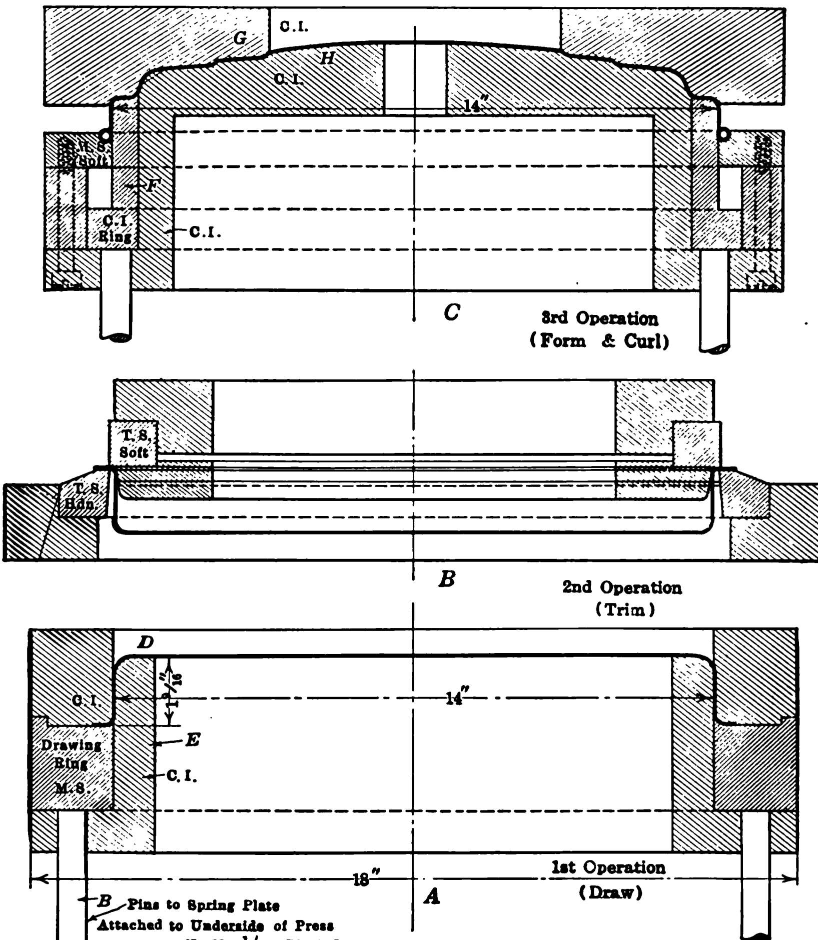


FIG. 284. — Dies for a large cover

around the cast iron base; the upper ring is bored a trifle under size, warmed enough to expand slightly, then placed over the shoulder on the upper die and allowed to cool and shrink in place. As these tools become worn, they are corrected by expanding the soft upper ring by peening with a hammer and refinishing by grinding to size.

The forming and curling dies are at *C* in the same drawing. When the

work is placed in the dies, it rests upon the top of cast iron ring *F* which is held up by the spring plate below the press bed. When the top die *A* descends, it forms the upper face of the cover to the form of the dies *H* and at the same time the work is put under pressure by the action of ring *F* so that as the upper die continues to descend and takes the pressure ring along with it, the work is supported properly and forced to curl around the concaved groove cut around the entire circle of the ring *J*. The latter ring the curling member, is of machine steel, and supported at suitable height by being secured to the top of a spacing ring *K*.

CHAPTER IX

COMBINATION AND COMPOUND DIES FOR BLANKING, DRAWING, FORMING, AND PIERCING

Combination dies, in their usual form, are adapted for performing in a single action press the operations of cutting a blank, drawing a shell, forming the end or edge, beading, etc., and sometimes a piercing operation is included. The work is accomplished at a single stroke of the press, the tools all being located about a common vertical center line as with the compound dies described in Chapter IV. The dies carry their own pressure pads, drawing rings, and knockouts and are set up in the press the same as a simple drawing die.

FIG. 285. — Combination dies for blanking and forming a shallow cover

A typical construction is shown in Figs. 285 and 286 herewith. These combination tools are for blanking, drawing, and forming the cover which in finished condition is shown in Fig. 287. The sketch, Fig. 286, shows the parts clearly. The blanking die edge is at *A*, the blanking punch at *B*. The draw post is at *C*, the draw ring at *D*. This rests upon a set of pressure pins *E* which extend down through the die shoe *E* to the pressure device *G*, which is fitted with a heavy spring that is regulated by nut *H* to apply the necessary pressure to the work held between *D* and *B* when the blanks are being drawn, to prevent wrinkling.

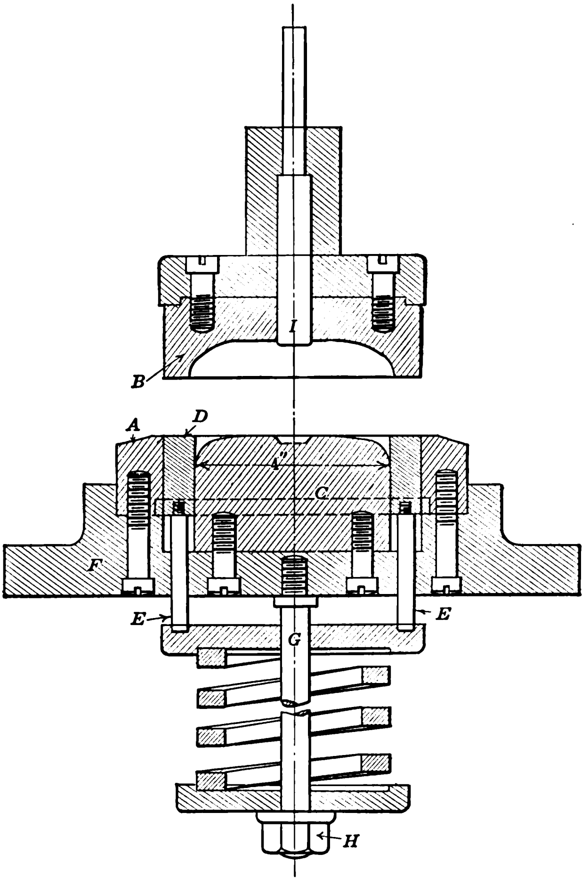


FIG. 286. — Section through combination die

FIG. 287. — The forming dies

The blanking die, the pressure ring, and the blanking punch are of tool steel, hardened. The knock out pin *I* which also indents the top of the cover is likewise of tool steel. The punch holder and die shoe are cast iron. The pressure pins *E* are drill rod. The plates or washers for confining the pressure spring are of machine steel.

The forming of the flange around the edge is attended to in the second operation dies, Fig. 287. A detail of the die arrangement is seen in the partial section, Fig. 288. Here the central member *J* of the lower die is adapted to be lifted by the pressure pins *K* to eject the work after the punch has started upward.

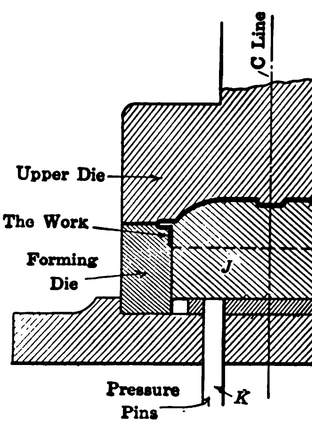


FIG. 288. — Partial view of forming die

PRESSURE SPRINGS AND PINS

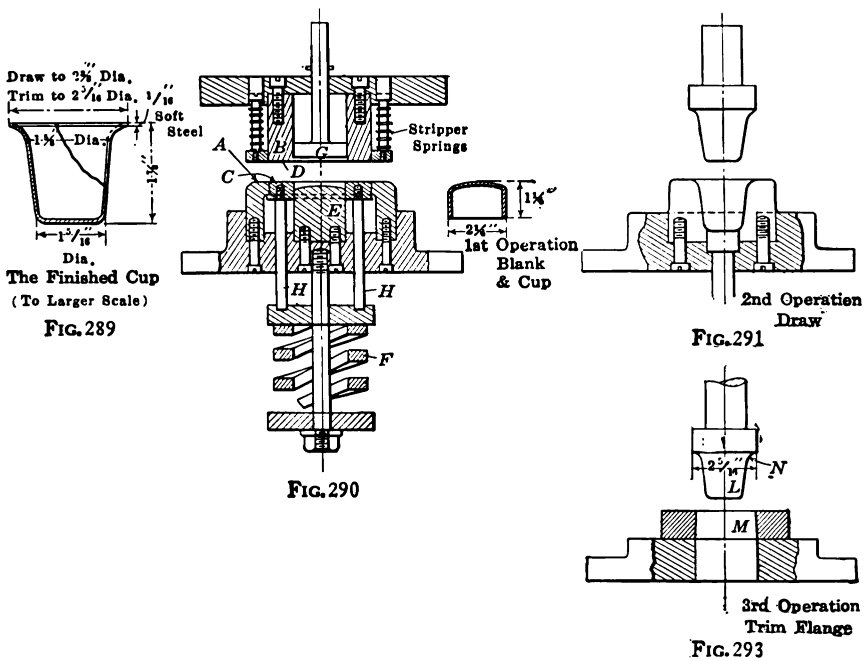
The number of pressure pins used about a die of the combination type varies with the size and form of the work. It may be that three will answer and it may be necessary to use four or more. The pressure device under the die shoe is equipped with the weight of spring necessary for accomplishing the work of controlling the pressure pad to give the desired tension to the material being drawn. In some instances the spring used must be of very heavy section. Rubber is often used instead of a coiled spring for this purpose, and some shops use it almost exclusively.

Where many dies of this order are in service it is customary to make up a number of these pressure devices and have them used interchangeably throughout a series of dies where fairly uniform conditions exist as to pressures required. Both the coiled spring and the rubber buffer types admit of considerable variation in the degree of pressure they transmit, through the medium of the adjustment possible by the nut on the threaded supporting stud. But often the range of work is such that a wide difference is required in the drawing pressures for different dies and several spring attachments with corresponding range in their working capacities are desirable, if not absolutely necessary.

A TAPER SHELL OPERATION

In Fig. 289 a tapered steel shell is shown which is made in three operations. The first is in the combination die, Fig. 290. Here the blank is cut and drawn to the cylindrical form shown in the detail with dimensions of $2\frac{1}{4}$ in. diameter by $1\frac{1}{4}$ in. deep. The blanking die is at *A*, the blanking punch at *B*. The metal is held by spring pressure between the upper

face of spring drawing ring or pressure pad C and the lower face of the drawing die at D, while the cup is drawn down over the drawing post E. The spring F is adjusted by the nut below to put sufficient tension on the blank so that it will not wrinkle as it is pulled down from between



FIGS. 289–293. — Dies for drawing and trimming taper shell

FIG. 292. — Dies for drawing a taper shell

faces C and D. On the upstroke, the ring C strips the work from the drawing post E and the knock out G clears the drawing die D. The pressure of the spring F is, of course, transmitted to the drawing ring C by the pins H.

The die and punch are of tool steel hardened, and the pressure pins are of drill rod. The die shoe is cast iron and the punch holder is a machine steel plate.

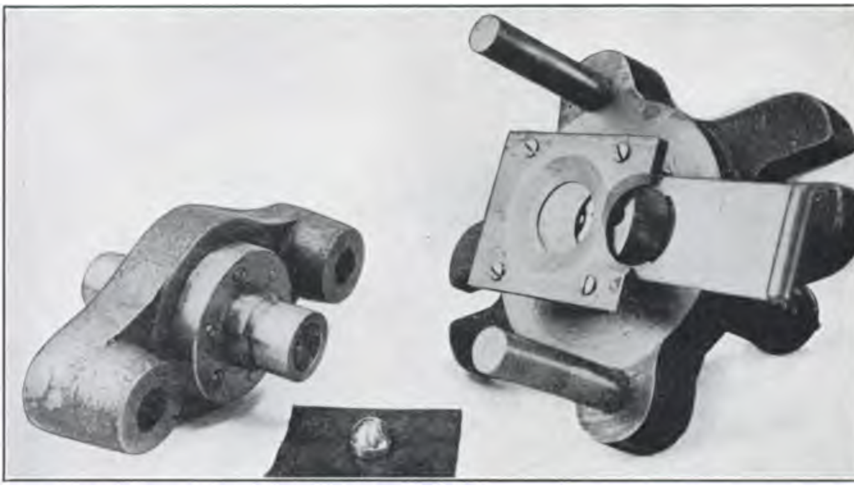


Fig. 294. — Tools for making a small bell

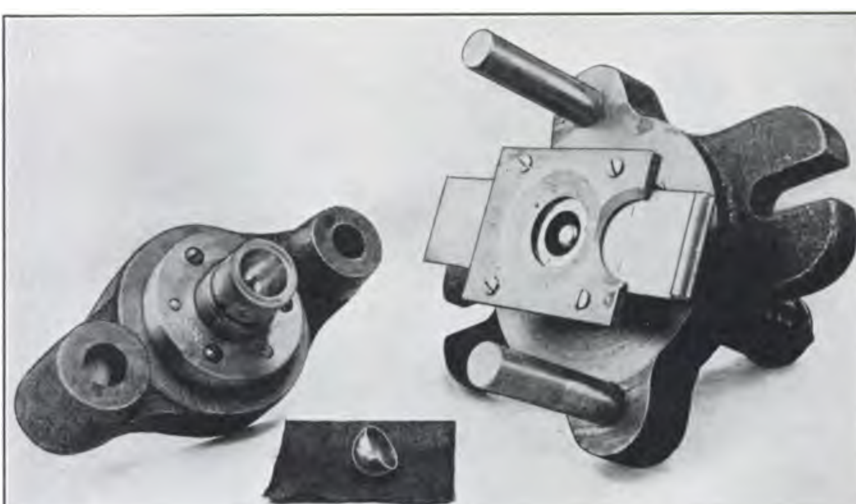


Fig. 295. — Tools for making a small bell

The second operation tools for tapering the shell are shown in Figs. 291 and 292. In the latter view a shell tapered to form is seen in the foreground. These tools require little explanation. The knock out in this case is in the bottom of the die and its head forms the lower portion of the

die proper. This set of tapering tools produces a flange that is about $\frac{1}{16}$ in. larger than required, leaving ample stock for trimming in the dies in Fig. 293. These latter dies are simply a piloted punch *L* to center the work and an open die *M* to trim the size desired for the flange. The trimming edge of the punch at *N* is given less clearance for the corresponding edge of the die than would be allowed for a blanking punch of the same diameter, on this thickness of stock, to prevent possibility of the narrow edge of the flange dragging into the die.

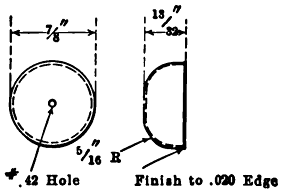


FIG. 296. — Detail of bell

TOOLS FOR A HEMISPHERICAL CUP

The tools in Figs. 294 and 295 are for blanking and drawing up the german silver bell seen in detail in Fig. 296. This is $\frac{7}{8}$ in. outside diameter and has a slightly flattened top. It is made of stock $\frac{1}{32}$ in. thick.

The two photographic views have been included to show more clearly the special slide for carrying the blank material into the dies. These bells are blanked out of slugs punched out in a piercing operation in making another larger piece. They are therefore fed into this die by a hand-operated slide having a nest the size of the slug and a definite travel back and forth to receive the slug conveniently and when pushed forward to center it over the die. The central position of the slide is shown by Fig. 295; the preceding photograph shows the slide withdrawn for another piece of blank material.

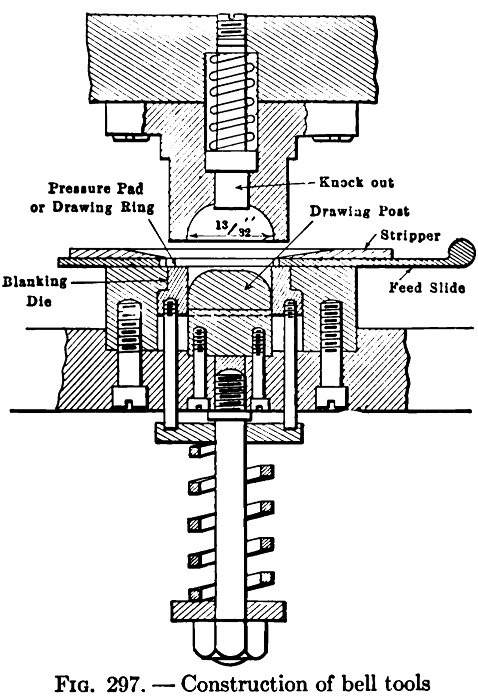


FIG. 297. — Construction of bell tools

The slugs from which the bells are blanked in these dies are enough larger than the blanking punch to leave a fair margin to prevent the rim of material dragging into the drawing die. The stripper over the slide and stock is beveled out for a half inch in all directions and the pressure pad or drawing ring comes flush with the cutting edge of the blanking die when the punch is up. The general features of the tools are well shown by the photo-

graphs and the sectional drawing, Fig. 297, and aside from the foregoing reference to the method of carrying the work into the dies little description seems necessary.

Making a Shallow Circular Housing

The press tools in Fig. 298 are for making a circular case which is used as a pawl housing on a coin register. The detail of the piece is shown by the sketch, Fig. 299. From this latter view it will be gathered that the shallow case or housing is made of $\frac{3}{32}$-in. soft steel which is drawn up to a cup $\frac{5}{32}$ in. deep inside, the outside diameter being $2\frac{3}{16}$ in. The blanking and drawing are accomplished in the combination tools, Fig. 300; the piercing of four holes seen in the detail is done in a second operation with the tools sectioned in Fig. 301.

The different elements of the dies, Fig. 300, that is, the cutting edge for the blank, the blanking punch, the drawing post, the pressure ring, the knock out for the punch, are all designated by name. All are of tool steel hardened. The pressure pins and pressure spring underneath are also indicated by their respective names and the entire construction will be clear upon inspection of the sectional view.

Owing to the fact that the shell is very shallow in proportion to the diameter and the thickness of the stock, the cutting punch is necessarily quite thin in its side walls, and for that reason it is made relatively short inside to give as much strength as possible. Inside this punch is carried the upper knock out which has a positive action upon striking the fixed stop on the press guides. The lower ejector is the same pressure ring that holds the material to the face of the drawing die to prevent wrinkling when the latter descends over the drawing post in the lower die.

This set of tools like the second operation set is fitted with guide pins similarly to the bell tools in preceding illustrations.

The second operation tools, Fig. 301, pierce the central hole in the cup and also three other smaller holes spaced from the center in accordance with the detail, Fig. 299. The piercing tools are fitted with a steel plate for the four punches as indicated and the punch holder carries a knock out device for operating the stripper which is made a close fit for the several piercing punches. The die is recessed out to give a depth of $\frac{1}{2}$ in. for the die top. The work locates over the top of the die which is ground to 2 in. diameter to suit the inside of the drawn piece.

The gap at one side of the work is cut out afterward in a milling operation.

Piercing Tools Combined with Blanking and Drawing Dies

Oftentimes the operation of piercing is combined in tools of this class with the blanking and drawing or forming of the piece A case of this kind is illustrated by Fig. 302, where a $\frac{3}{32}$-in. cap is shown as drawn and pierced with the tools in Fig. 303.

FIG. 298. — Tools for a shallow housing

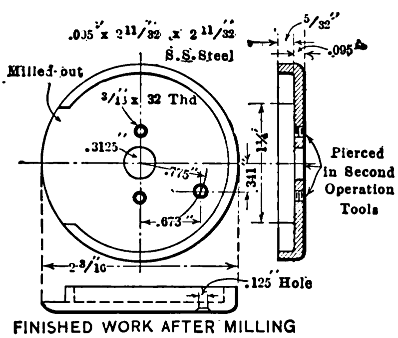


FIG. 299

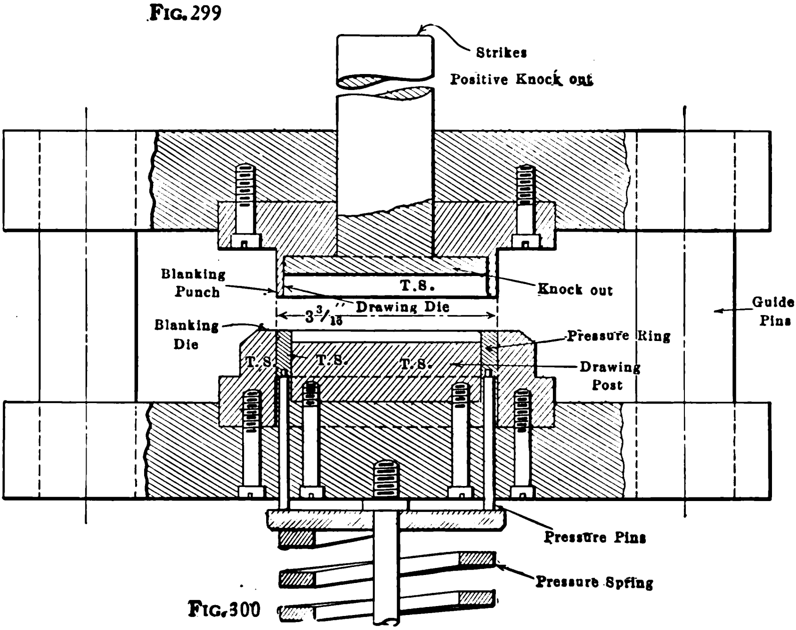


FIG. 300

FIGS. 299–300. — Dies for first operation on pawl housing

The cap is $2\frac{5}{8}$ in. inside diameter and $\frac{5}{8}$ in. deep. It is a gear shifting lever tower cap for automobiles, and has three small holes spaced near the rim and a larger hole through the center. The dies blank, draw, and pierce in a single action press.

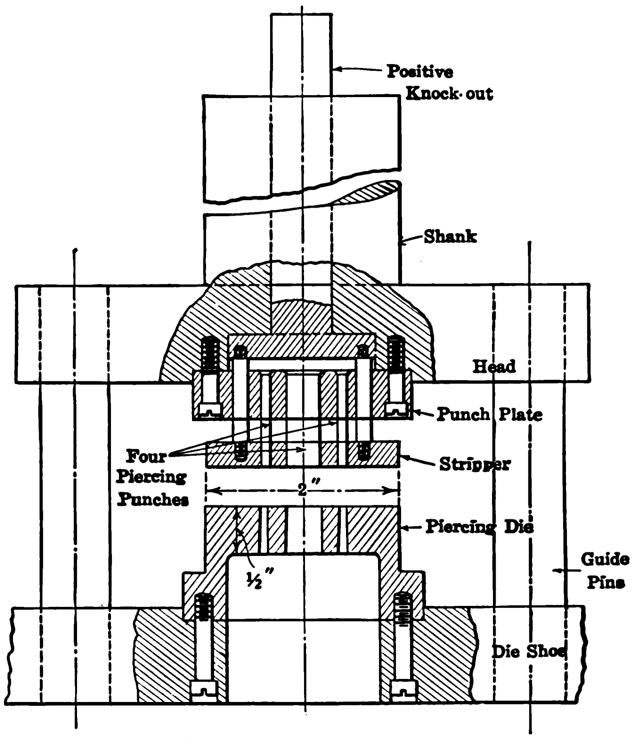


FIG. 301. — The piercing tools

The die is constructed as follows: The blanking and forming punch A which is of tool steel, hardened and ground, is fastened to the cast iron punch holder B. The blanking die C is of tool steel hardened and ground and seated in the cast iron base D. The piercing and forming die F is also seated in the base. The piercing punches G are shouldered to resist the force required for piercing, and are held in place by headless set screws. The stripper H, which strips the scrap from the blanking punch, is suspended from the punch holder by six special screws I, which also serve as retainers for the stripper springs.

A rule that has been used successfully for the calculation of the stripping pressure required is to take this at approximately 7 per cent of the blanking pressure. The upper knock out K is held in alinement with the punches by the three pins L, abutting against the disk Q, which transmits the spring pressure from the three springs R to the blank holder. The

spring tension is adjusted by the nuts *S*. The guide pins *T*, which are of different diameters to prevent missetting of the die, are a press fit in the base and a sliding fit in the punch holder. The shank *U* is fastened in the ram of the press.

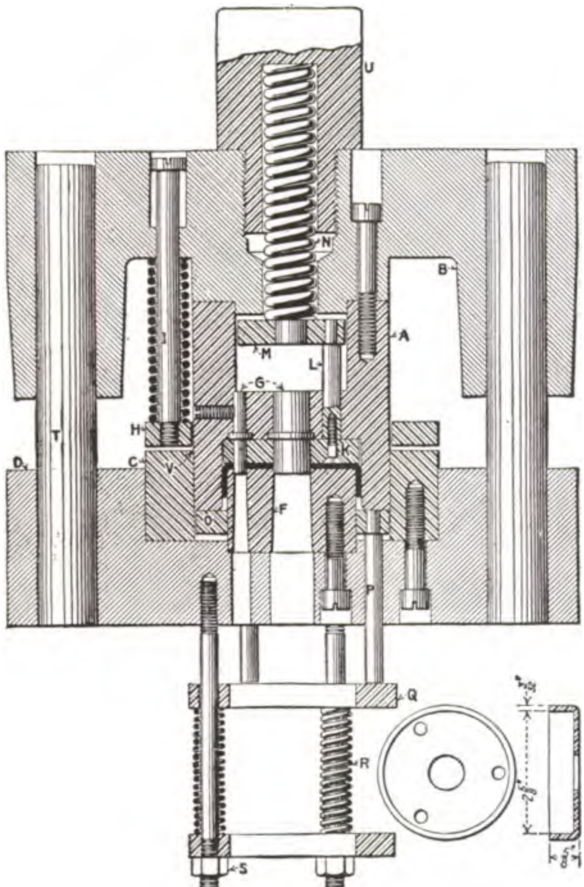


Fig. 302 Fig. 303

Figs. 302–303. — The cap and details of the die

The operation of the die is as follows: The blank is cut from the strip by the punch *A* at the point marked *V*, and is held under tension between the punch *A* and the blank holder *O*. The punch *A* continues down, forming the cup around the die *F*. The punches *G* then pierce the holes; the knockout *K* serves as a bumper, flattening the face of the cap. On the return stroke, the scrap is stripped from the punch *A* by the stripper *H*. The cup is pushed up flush with the blanking surface *V* by the stripper *O*. The knockout *K* ejects the cap from the punch. It is essential to secure an even edge on the cap. No trimming is required with this type of die.

Dies for a Valve Spring Cup

The cup in Fig. 304 is formed with a channel around the base of the flange and a $\frac{3}{8}\frac{2}{4}$-hole is pierced through the center of the piece.

In the construction of the dies for this work, see Fig. 305, the blanking and forming ring *A*, is seated in a base *B*; the blanking punch *C* which serves as a guide for the forming punch *D* is fastened to a cast iron holder *E*. The part *F* strips the scrap from the punch. The knockout *G* is supported by four push pins *H* abutting against the washer *J*, which serves as a retainer for the spring *K*, the tension of which is regulated by adjustment of nut *L*. The stud *M* which supports the knockout arrangement is drilled through to allow the scrap punchings or slugs to escape. Slots are cut in the top face of the punch holder to prevent the entrapment of air in the guide pin bushings.

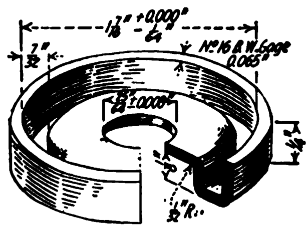


Fig. 304. — The spring cup to be made

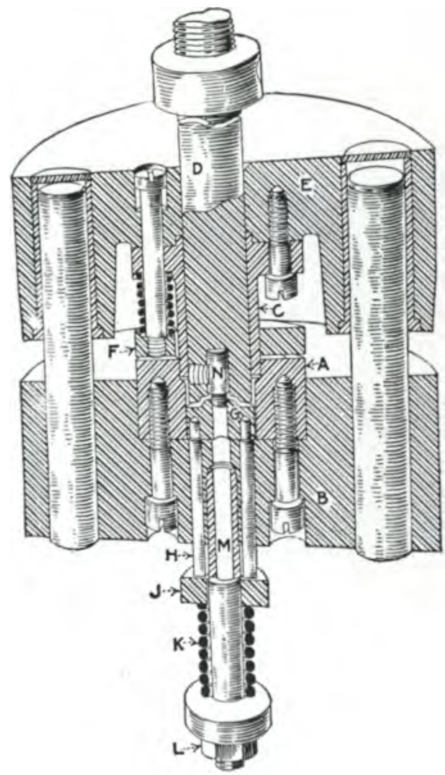


Fig. 305. — The combination die used

In operation, the blank is cut from the strip by the punch *C* and forced down to the draw edge. The forming punch *D* and the piercing punch *N* then descend, completing the cup. As the press ascends, the punch *D* disappears through the opening of the blanking punch *C*, stripping the cup, while the knockout ejects the cup from the die ring.

Muffler Cup Tools

The combination blanking, drawing, forming, and piercing die in Fig. 306 is used in a single acting press for making muffler cups for automo-

biles. The parts are all designated by name to permit of easy reference, and a brief description of the action of the tools will suffice.

When the blanking punch descends, it enters the blanking die, and the blank is held firmly by the drawing ring against the bottom of the blanking punch to prevent wrinkling. As the downward movement continues, the

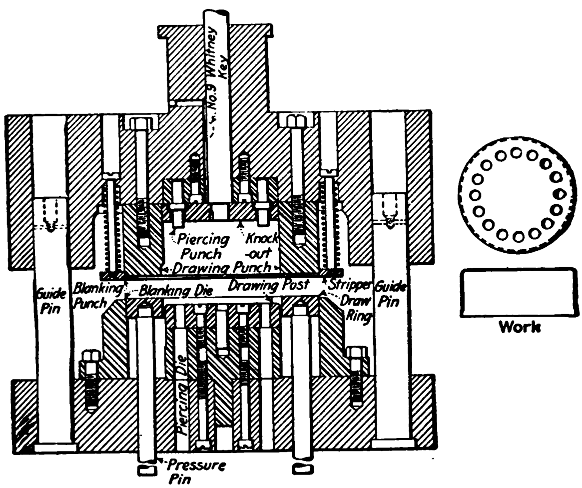


FIG. 306. — Blanking, drawing, forming, and piercing die

blank is drawn between the bore of the blanking punch and the drawing punch. As it reaches the end of the stroke, the rim is formed between the shoulder in the blanking punch and the tapered shoulder on the drawing

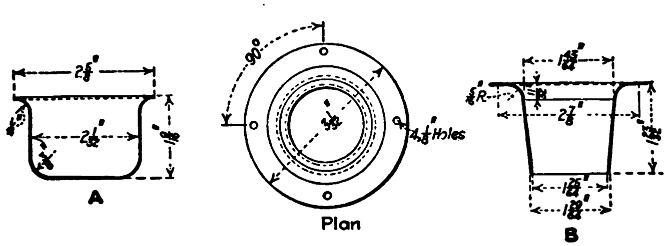


FIG. 307. — Brass coupling, No. 20 gage

punch. The holes are pierced by punches located in the punch block and the dies in the base below. A spring stripper is used as represented. The knock out is kept in line with the piercing punches by a Whitney key.

SET OF TOOLS FOR A BRASS COUPLING

The pressed brass coupling in Fig. 307 is drawn in two operations. The first operation *A* consists in blanking and drawing from a $4\frac{3}{4}$-in. blank in the dies shown in Fig. 308. These tools are set up in a single action

press and the shell must be drawn to a developed depth in order to correspond properly with the next operation dies so as to give the desired results.

In setting up this die, care must be exercised in adjusting the rubber buffer *N*. Too much stress on the pressure pad *F* would strain, stretch, and possibly break the brass, while not enough stress on the pressure pad would permit the metal to wrinkle and cause breakage and poor work

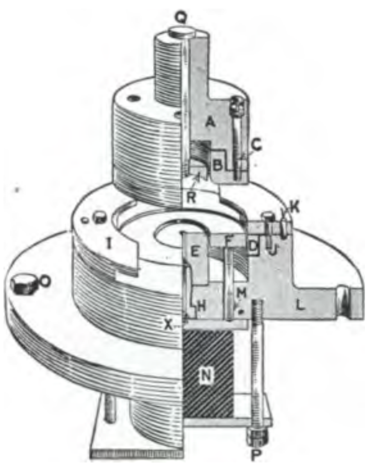


Fig. 308

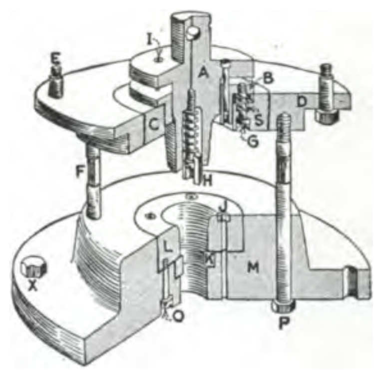


Fig. 309

Figs. 308–309. — Dies for a pressed brass coupling

in the operation that follows. The lower punch *E* in the die has a small vent to facilitate the removal of the work from the punch and prevent distortion.

The blanking punch *A* has a positive knockout that comes in contact with the stationary knockout bar attached to the press while in operation. Should the shell stay in the punch, it is easily released on the upward stroke. The compound blanking and cupping punch *A* is made of machinery steel with a tool steel bushing *B* pressed into place and secured by screws *C*. The bushing *B* which does the actual work of blanking and cupping can be shrunk several times when it wears large and is easily replaced with a new one when this becomes necessary. A punch of this type, when its diameter exceeds 4 in., is cheaper and has a longer life than a solid tool steel punch, because the bushings can be shrunk to size so often.

The blanking punch *D*, the forming punch *E*, and the pressure pad *F* are made of tool steel, hardened and ground to size. The forming punch *E* is held in position by the bolt *H*, which has a vent similar to that in the punch *E*. The outlet is at *X*. The blanking die has $\frac{1}{16}$ in. shear and is held in position by machine steel strippers *I*, in turn held in place by cap screws *J* and dowel pins *K* seated and screwed to the cast iron die plate *L*. The latter is secured to the bolster plate by cap screws *O*. The pressure

pad pins M are made of hardened and ground tool steel and transmit the pressure to the pad F from the rubber buffer N, which is adjusted by the lock nuts P.

The second operation, indicated at B, Fig. 307, is performed in the drawing and perforating dies shown in Fig. 309. These dies draw the tapered shell B with a flange concentric with the walls of the shell, perforate four rivet holes in the flange, and punch out the bottom simultaneously. Thus the coupling is finished in two operations. By using a die of this type, trimming is unnecessary, so that it is possible to use a smaller blank, thereby saving valuable stock and completing the article in the briefest possible manner.

The drawing punch A, of tool steel, hardened, has double stripper bushings BC, made of tool steel, hardened and ground. The bushing C, connected with the bushing B by springs and screws G is screwed and pinned

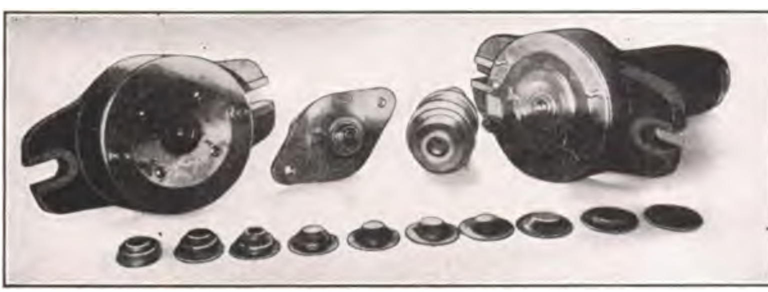


Fig. 310. — Dies for a brass bushing

to the machine steel stripper bar D, which is held in place on the punch by the bolts E screwed to the ram of the press. When these bolts are properly adjusted, they give the correct sliding motion on the punch to release the stamping during the last $\frac{1}{4}$ in. of the upward travel of the press ram.

It is obvious that when the punch descends and enters the shell X the plug H (of tool steel, hardened and ground), having the proper spring tension will straighten the shell in the bushing C. This tension from the spring S causes the bushing C to close on the die on the last $\frac{1}{4}$ in. of travel of the punch, which is necessary in order that the surplus flange stock may be properly forced into the die and down along the sides of the draw punch, assisting the drawing and perforating the flange holes.

The punch A is straight for $\frac{1}{32}$ in. above the curve on the lower end to allow for the necessary over travel to upset the end of the coupling slightly and prevent it from having a feather edge. The perforating punches I are made of tool steel hardened and ground, and screwed into place by having their heads threaded and slotted. The perforating punches J

are made of tool steel, hardened, ground, and pressed into place. The bushing *K* is likewise of tool steel, hardened and ground. It is held in place by the drawing die *L*, which is seated in the cast iron die plate *M* and secured by the screws *O*. The die plate is fastened to the press bed by cap screws *X*.

A Brass Bushing Outfit

The brass bushing at the extreme left of the parts in the foreground of Fig. 310 is blanked, drawn, and pierced by the tools at the right in the same photograph, and is then trimmed in the other dies at the left in the same engraving. A detail of the bushing is shown in the drawing, Fig. 311. The first operation tools are shown complete in the drawing, Fig. 312, and all details are included.

Referring to this drawing, the cutting edge of the blanking die is shown at *A*, and inside of this die is the compound drawing plug and ring *B* with

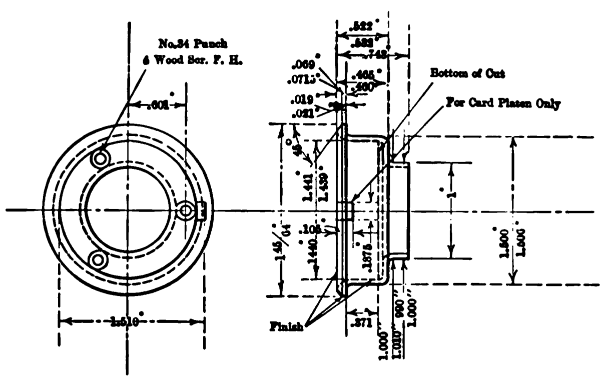


Fig. 311. — The brass bushing finished

the friction ring or pressure ring *C* filling the annular space between. The drawing plug *B* rests upon pressure pins *D* and the ring *C* upon longer pressure pins *E* which pass down through holes in the base of plug *B* and abut upon pressure plate *F* which acts uniformly upon both sets of pins *D* and *E*. Plate *F* is controlled by the rubber buffer or spring *G* which is secured between *F* and a lower plate *H*, the latter being adjusted by the nut on the supporting length of tubing to allow the rubber to apply any desired degree of pressure to the friction ring and plug *B* above.

The blanking punch *I* is bored out and ground to 1.560 in. to form the drawing die inside for the larger diameter of the work and in this is fitted the die *J* which draws up the smaller diameter at the end of the work. The latter die is adapted to slide upward for a distance of $\frac{1}{3}\frac{3}{2}$ in. and upon the upstroke of the punch it is forced downward to flush position by the pins *K* and the knockout plug *L* above. In the center of the punch holder is pressed snugly the piercing punch *M* which may be adjusted for depth

of position by the screw N. The die J is stopped for lower position by the ring O which encircles the blanking punch and which carries three screws passing through vertical slots in the punch wall and entering holes in the die J.

The piercing die is located at P in a seat bored in the die shoe or base and is relieved from the lower end to give a cutting length at the top of only about $\frac{1}{4}$ in. as shown by the detail at P.

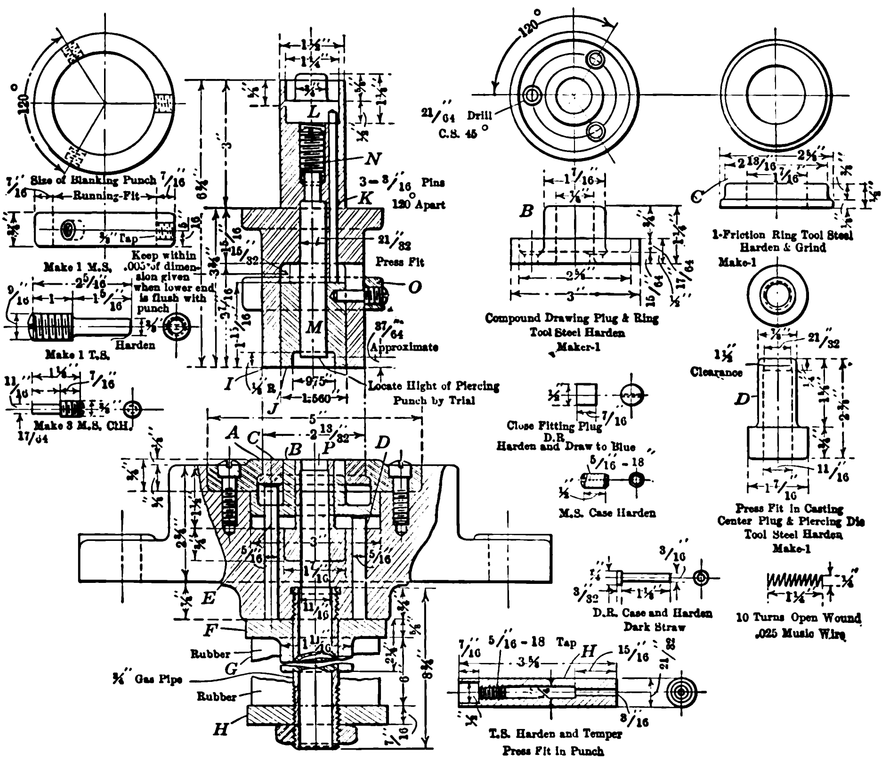


Fig. 312. — Details of combination blanking and drawing dies

The dies are seen in Fig. 313 as they appear with the work in place and drawn to shape for the two diameters and the hole pierced through the end. The same letters are here used for reference as in the other drawing just referred to. The top surfaces of spring controlled members B and C act as friction surfaces or pressure rings to allow the two sizes of draws to be made without wrinkling of the metal. When the punch holder (which is made in one piece with the blanking punch I) rises, the knock out K and ring O are actuated to eject the work from the upper dies. The scrap is stripped from the blanking punch by open stripper plates attached to the lower die face as shown in the photographic view, Fig. 310.

The Second Operation Dies

The trimming dies are illustrated by Fig. 314 and Fig. 315 shows the work in place and ready for the trimming of the edge in die *Q*. This die (refer to both drawings) in conjunction with punch *R* trims the edge of the shell to 1.782 in. diameter. This leaves a small amount of stock which is finished to a perfect beveled edge in a later operation in a screw machine where the inside of the shell is turned out to a positive diameter and the end faced exactly to length, in accordance with the drawing of the finished piece in Fig. 311.

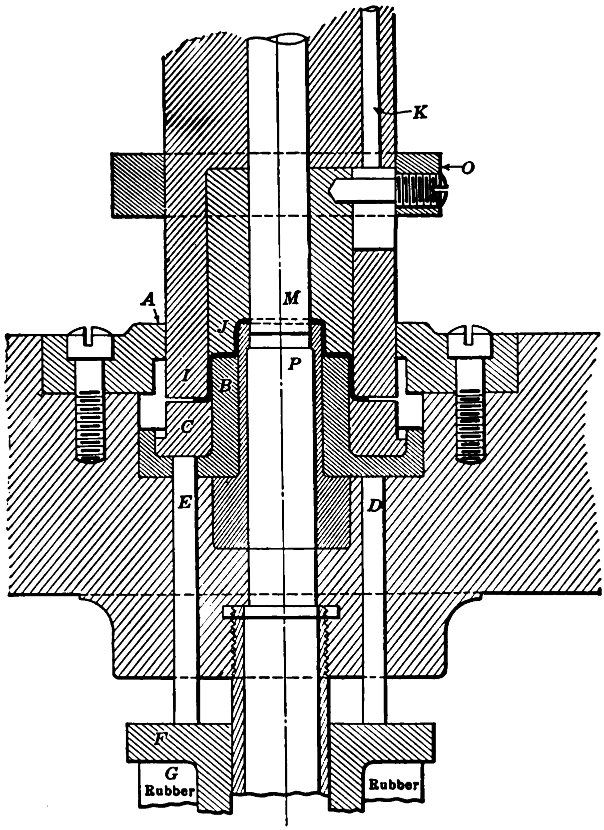


Fig. 313. — Blanking and drawing dies in operation

Referring again to Figs. 314 and 315, the work is centered by the piloted punch *S* screwed into the punch holder. This holder like the other is of tool steel and its lower end is finished by turning and grinding to form the holder for the work. This portion of the punch also carries the combined trimming punch and stripper *T* which is connected with

the cross plate *U* which in turn is connected with the lower die base by two sliding bolts *V* which prevent the stripper from rising beyond a certain point on the upstroke of the press ram.

On the down stroke, the locating punch *S* and the punch holder descend, as in Fig. 315, until the work is secured against the face of the trimming die

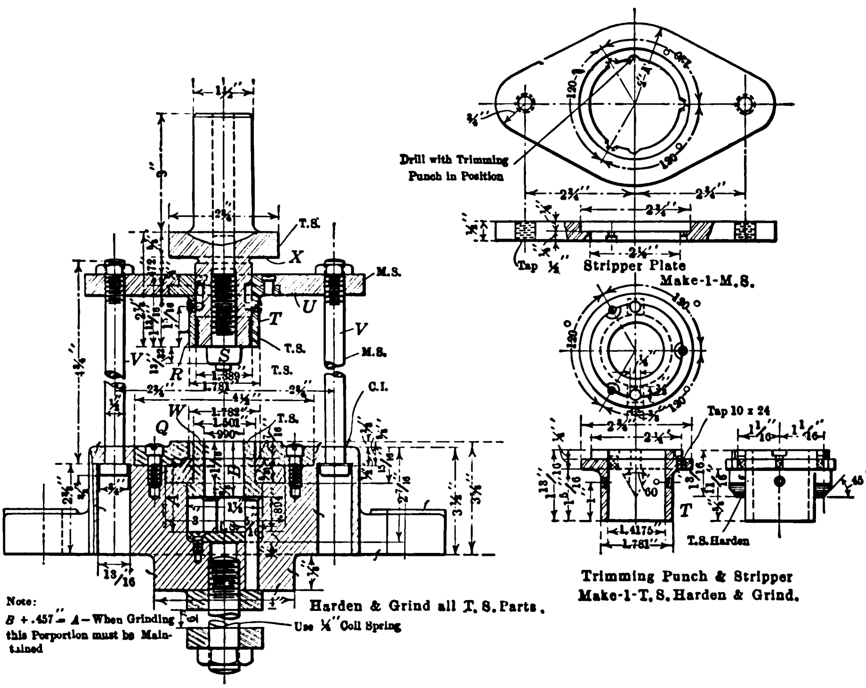


FIG. 314. — Construction of trimming dies

pressure pad *W*, the top of the stripper plate *U* is then against the lower face of the punch holder shoulder *X* and the trimming punch *R* must then travel downward with the rest of the upper tools. The pressure ring *W* is forced down against the spring pressure transmitted by pins *Y* and the work is held securely while being pushed into the trimming die *Q*.

On the upstroke of the ram, the pressure ring *W* carries the work out of the trimming die *Q* and when the stripper plate *U* reaches its limit of travel upward, as determined by the stop bolts *V*, the punch holder continuing upward, causes the ring and stripper *R* to strip the work from the punch. The stripper ring is provided, as shown in Fig. 314, with two wedge shaped points at the sides to split the thin ring of scrap trimmed off from the work as it accumulates on the surface of the punch and thus keep the punch clear.

It is evident that dies of this class must be set up in the press with some

care to effect the desired results. Particularly with the first operation dies which draw two different diameters, judgment must be used to adjust the different elements properly to assure the correct distribution of metal between the two sizes drawn on the one shell. To facilitate the setting operation the set of standard pieces or models shown in the foreground of

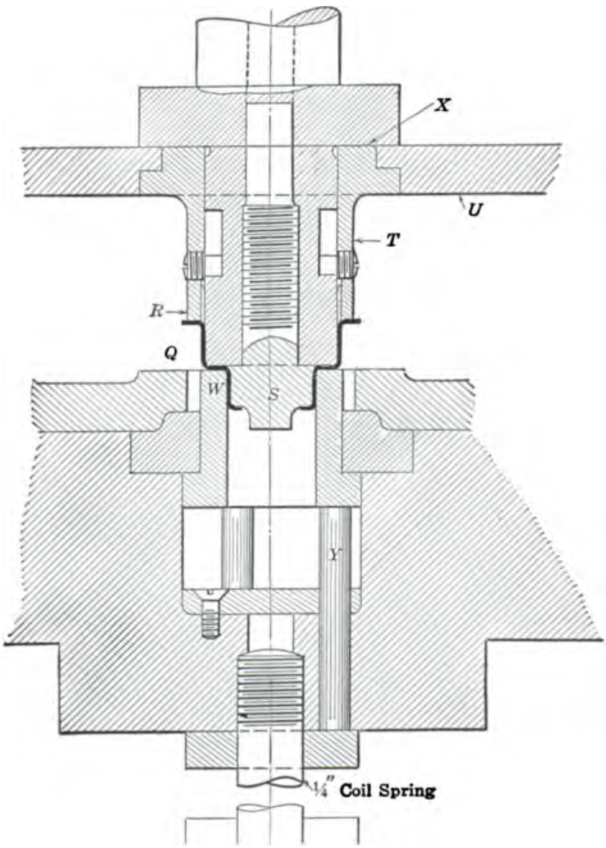


FIG. 315. — Trimming die in operation

Fig. 310 are kept available. These pieces are made up to represent correct heights and sizes of draw for the shell for every sixteenth inch of movement on the part of the press tools. Thus, when the tools are being set, the operator can draw a blank to the first sixteenth of depth and compare results with the model parts used for comparison gages, and so on with the setting adjustments until each advance of the amount specified, or $\frac{1}{16}$ in., produces a partially drawn shell corresponding in all dimensions with the models, or masters shown, and the completed trial piece becomes a duplicate of the full drawn model.

Drawing Fine Wire Mesh

One more example of a set of blanking and drawing tools will be shown in this chapter. The tools in Fig. 316 are for an unusual piece of work, a fine meshed copper wire screen for a carburetor. This would appear to be difficult material to work in the press, but with the tools illustrated no trouble whatever has been encountered.

The wire screen is shown in Fig. 317 somewhat more clearly than in the view of the dies. The dimensions are given in the sketch, Fig. 318, which

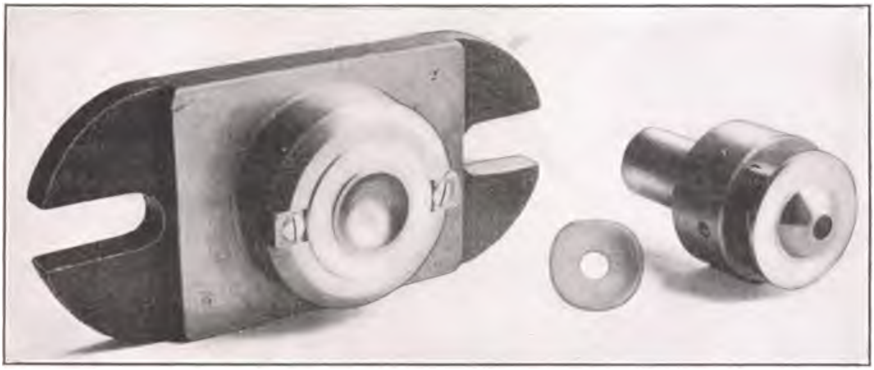


Fig. 316. — Tools for a fine mesh screen for a carburetor

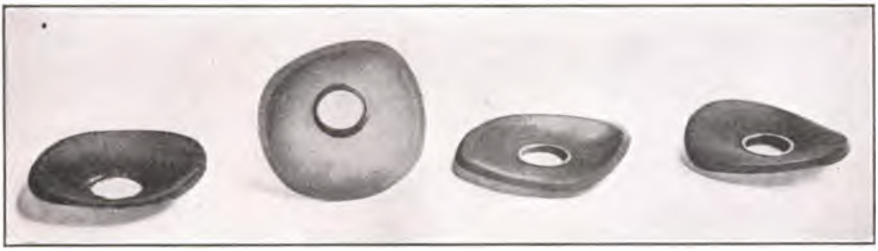


Fig. 317. — The small screens as they appear when fitted with center ring

shows a vertical section through the dies. The wire screen is drawn up to a diameter of $1\frac{3}{4}$ in. and to a depth of about $\frac{5}{8}$ in.

The tools are so made that although they blank and form and pierce in one operation, the drawing operation, or forming, is accomplished first, the wire being pressed down into the spherical seat in the pressure pad *A* and held there by the punch *B* and the action of the pressure pins *C* and the rubber buffer *D* below, while the blanking is done with the cutting edge of the punch and the blanking die *E*. At the same time the piercing punch *F* pierces the hole through the center, the piercing die being formed at *G* in the center of the punch *B*.

The stripper is carried at H on three small screws with springs between stripper and punch holder, J. As the work leaves the dies it tends to spring back to an approximately flat form, as seen in Fig. 317, and it will

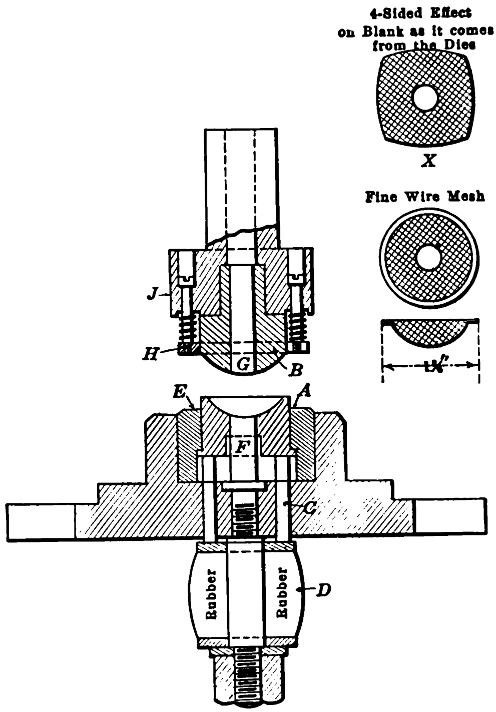


Fig. 318. — Construction of tools for screen

be noticed that the outline of the screen is four sided with slightly rounded edges but otherwise closely resembling a square piece. When assembled in the carburetor it is placed in a circular seat and there retains its hemispherical form. The brass eyelet shown at the center is, of course, set into place in a subsequent operation.

CHAPTER X

BENDING AND FORMING TOOLS

Bending dies in their simplest form consist of a plain, open set of tools, like those in Fig. 319, which are illustrated as used for bending up a slender steel part which forms a bell tapper arm for a calculating machine. The piece itself is shown by Fig. 320 as it appears when attached to the tapper. It is made of half hard steel 0.050 in. thick and the blanking dies for producing it are shown in Fig. 40, Chapter II.

The bending dies, Fig. 319, are provided with a locating nest at the top of the bending V in which the head of the blank is seated, while the long

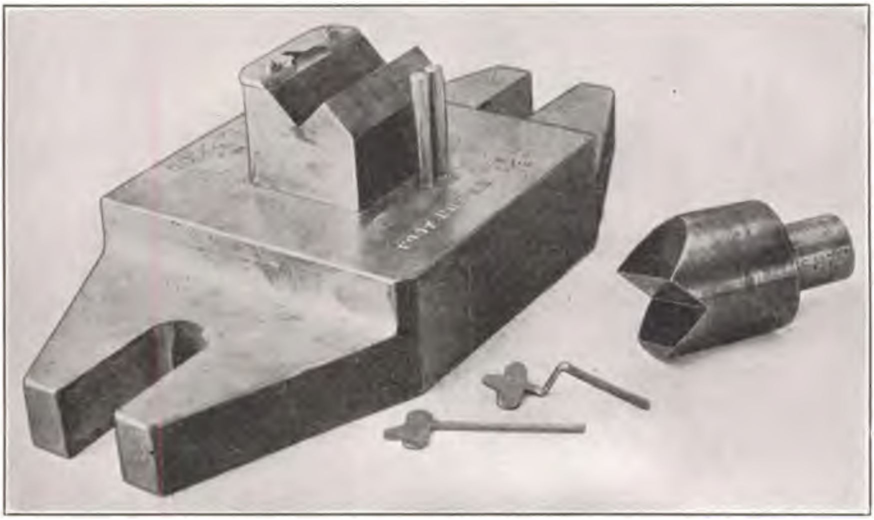


Fig. 319. — A plain bending die

arm is slipped between two guide pins in front of the V-block. The punch is formed with a similar V and one stroke of the press forms the straight blank into the piece with two right angle bends so that the projecting arm is thrown again parallel to, but offset from, the clover shaped head. These tools, like many similar dies, are used in a foot press.

The die base is a cast iron member, and the die proper is of tool steel hardened. The punch or upper die is also of tool steel hardened. The work before and after bending is seen in the foreground of the photographic view.

Use of the Spring Pad or Knockout

The dies shown require no pressure pad or knockout, owing to the form and proportions of the work. There are many instances, however, where even the simplest pieces are bent with greater convenience by the addition of a knockout to the dies and in many other instances the knockout or some other form of spring actuated device is absolutely necessary. This is also essential for locating and holding the blank in many cases.

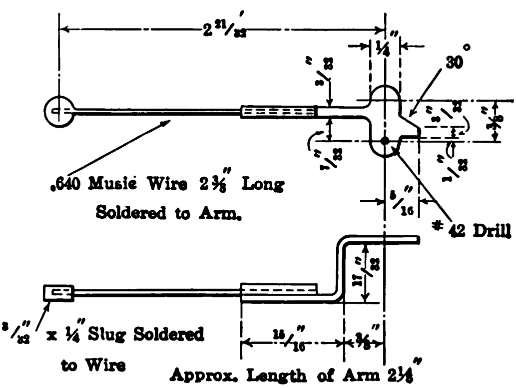


FIG. 320. — The piece bent in the dies Fig. 319

A simple piece of bending work with a spring pad in the dies is shown by Fig. 321. The work is a $\frac{3}{16}$-in. steel rod with one end bent up to a length of $\frac{13}{32}$ in., the body being $4\frac{9}{16}$ in. long. The dies require little description. They are made with guide pins for alinement and rigidity and

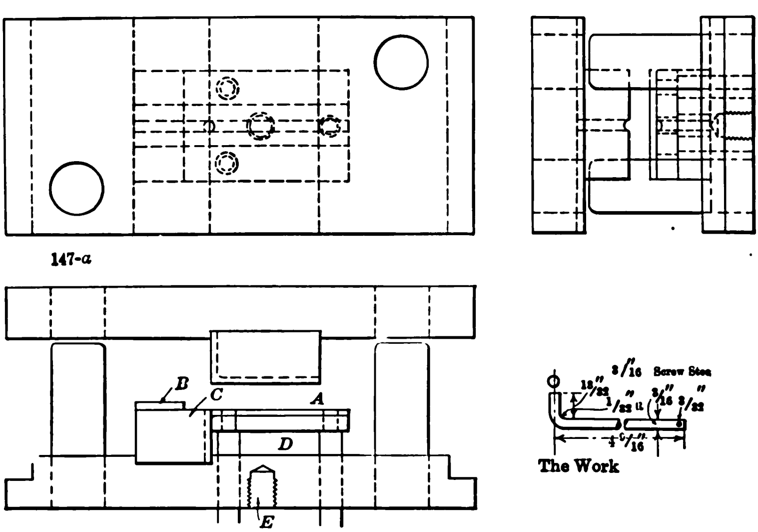


FIG. 321. — Bending dies for a round rod

the upper and lower dies proper are concaved for one-half of the diameter of the rod in each face. The pad A is provided with a similar half round groove and the work is readily located by slipping it into this concave seat and resting its inner end against stop shoulder B. On the down stroke, the

rod is forced down over the rounded corner of lower die C and formed to the right angle bend desired. When the upper die ascends, the spring pad A lifts the work clear and is ready for another blank. The dies and pad are made of tool steel and hardened.

The pressure pins D are actuated by a spring pressure attachment whose supporting stud screws into the tapped hole in the lower die shoe at E. This is similar to the usual spring attachment used with various classes of dies already shown in this book and need not be detailed here.

Bending Two Ears on a Blank

In Fig. 322 (at the right) are a pair of dies for bending up two lugs or ears on a bracket shaped piece shown in detail in Fig. 323. This is pierced and blanked with the tools at the left in Fig. 322, the form of the blank being clearly represented in the detail sketches. The piece is made from

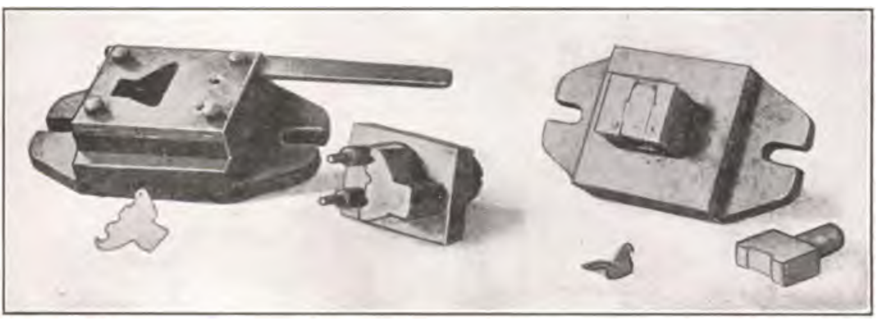


Fig. 322. — Blanking, piercing, and forming dies for a small bracket

$\frac{3}{64}$ in. steel, and has two $\frac{1}{8}$-in. holes pierced in the end which are later used in the finished work for receiving a rivet or pin for hinging another member between the bent up arms.

The two pierced holes are made use of for locating the blank on the bending dies shown more fully in Fig. 324. The die proper here is seen at F and the punch or upper die at G. Die F is cut out midway of its width to receive a pressure pad and ejector H which is formed at the front end to give the downward bend to the lip of the blank. In this way it is made to form part of the die itself in that it performs a portion of the work of shaping the piece to dimensions. A counterpart of the bend, but in the reverse direction, is formed on the end of the punch G. The latter is naturally less in width than the opening O across the die face by an amount equal to twice the thickness of the material. As with drawing dies it is desirable to give the corners of the bending dies a liberal radius to enable the work to pull over and down the side of the die without breaking or tearing. This also enables the bend to start easily.

As the punch comes in contact with the blank, the projecting ears on the blank swing upward and release the work from the very short locating pins *J* and the punch continuing downward presses the blank down between the die jaws and forms it to shape. With the return of the punch, the spring pad *F* carries the work up and out of the die.

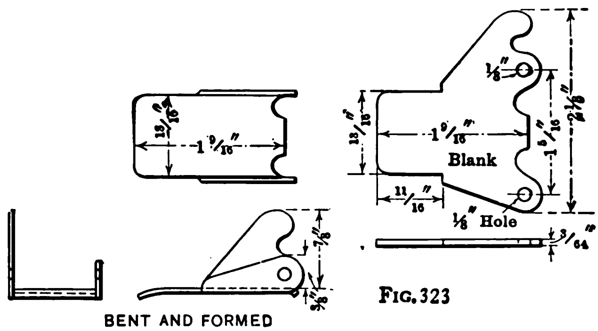


FIG. 323

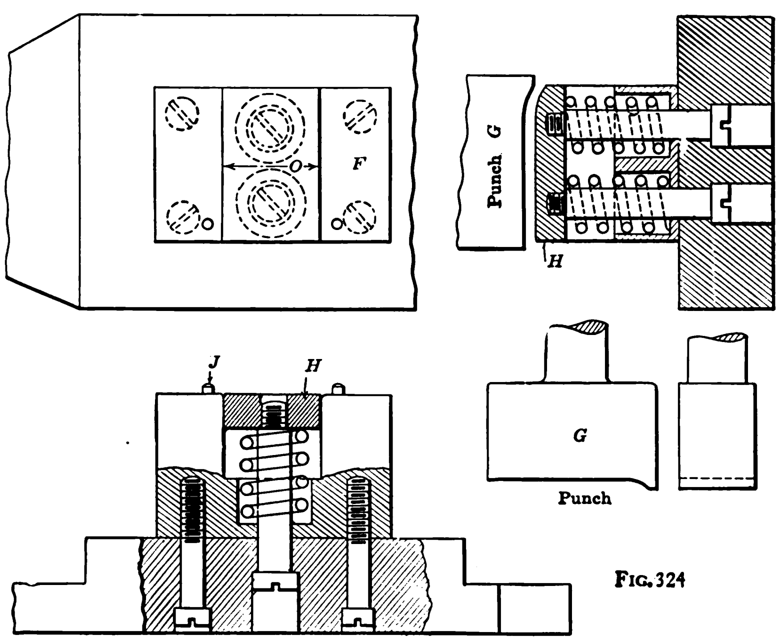


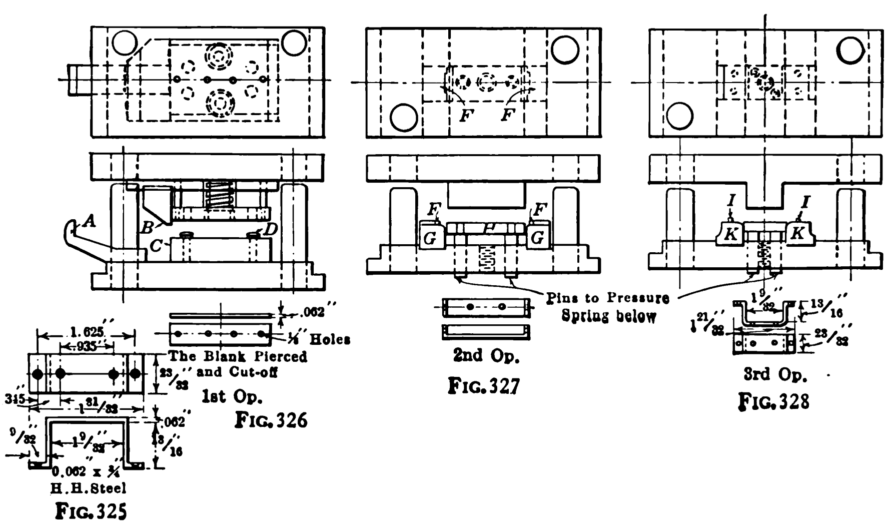
FIG. 324

FIGS. 323–324. — Construction of bending or forming die

A Double Bending Outfit

Where simple tools are preferred it is often necessary to use two or more sets of bending dies for performing the same number of distinct operations on a piece. With compound bending tools parts requiring complicated bending and forming operations are completed in one setting.

The work shown in Fig. 325 is a steel bracket $\frac{1}{16}$ in. thick which is blanked and pierced in the tools, Fig. 326, where the blanking operation consists in shearing off the end of a strip of the right width and piercing the holes at the same stroke of the press. The end of the strip rests against stop *A* after the first stroke of the press and this gives the right position for cutting off to length by the shearing punch *B* and the cut-off end of the die *C*. With such small punches, as are here used, it is desirable to have the cut off punch act first before the piercing punches enter the work, thus preventing the latter from being injured or broken. The strip of material rests between the gage studs *D* while in the dies and the four gage stops thus hold the strip central and square during the operation. Their heads also form a stripper.



Figs. 325–328. — Dies for double bending operation

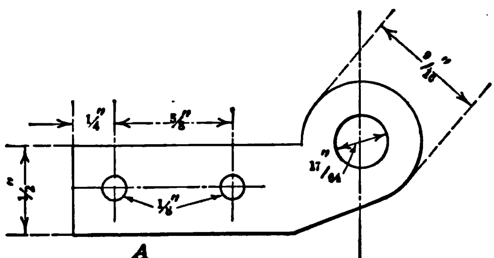
The first bending operation consists in turning up the ends to a right angle with the dies in Fig. 327. Here the blank is placed in the die with the ends between stop surfaces *FF* which form a locating nest while the punch descends and draws the work down between the bending jaws *GG*. The knock out *H* is supported by two pins which abut upon the spring pressure device below, and when the punch ascends, the spring pins carry the work up for removal and transfer to the next operation dies, Fig. 328.

Here the work rests over the two gage pins *II* and the punch in descending performs the second bending operation by forcing the middle of the bent blank down between die jaws *KK*, where the body of the piece is formed to the outline indicated in the sketch of the third operation. The action of the knock out is the same as with the one in the first operation die

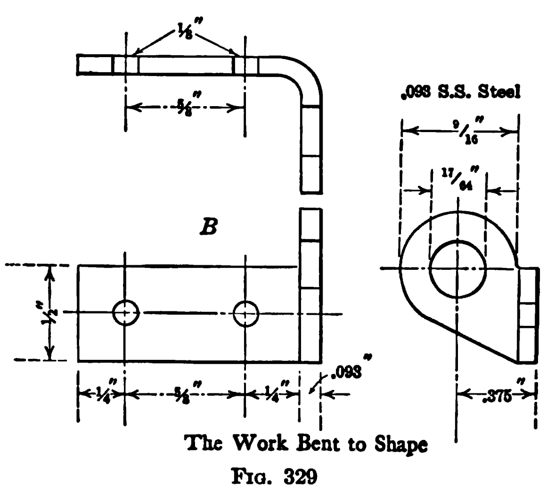
Fig. 327. The die jaws, punch, and strippers here are of tool steel, hardened, the pressure pins of drill rod hardened, the die base and punch holder are machine steel plates finished to 1 in. in thickness.

The Pressure Pad on Top of the Work

It is occasionally the case that the die is designed to hold the work blank on top of the anvil or flat part of the bending die by means of a pressure pad while the punch or upper die is engaged in bending some pro-



A
The Pierced Blank



The Work Bent to Shape

Fig. 329

jecting portion of the piece. In this case the work is placed in some form of nest or located over gage pins, and when the punch descends, the pressure pad holds the material firmly for the forming of the bent portion. An example is illustrated in Fig. 329 which is a sketch of a small bracket for a register device, where the round end is bent at right angles to the body.

The piece is pierced and blanked in progressive dies in an earlier operation and the form of the blank is shown at *A*. The shape of the member after bending is seen at *B*. The material is 0.093 in. soft rolled steel.

The bending dies are shown in Fig. 330. The work is placed over the two pins in the face of the die block C and is held squarely by these pins for the application of the bending punch D. As the punch holder descends, the pressure pad E which is backed up by a very stiff spring, is forced down upon the work and held securely during the folding down of the end over the edge of the die. When the punch rises again, the pressure pad follows it and the work is released.

Two blanks are bent at once in these dies. This means a wider pressure pad than would be required for a single blank and the proportions of the pad are therefore made such that two springs may be used and a better

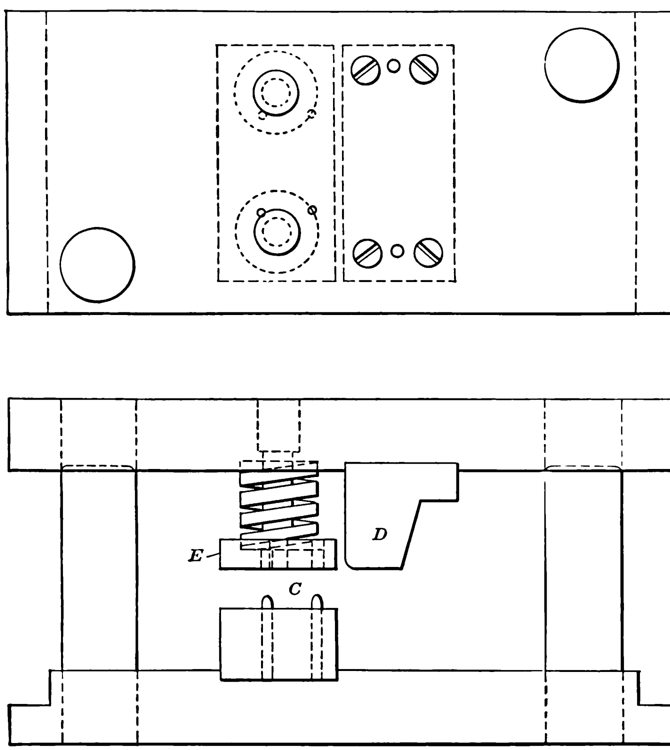


FIG. 330. — Bending dies for a light bracket

balanced action is thus made possible. The work is placed and removed as readily as a single blank would be and there is a great advantage in output from this arrangement.

The desirability of the guide pins for the punch and die bases is obvious as without them there would be much sacrificed in the way of rigidity of the tools. The pressure and thrust all being in one direction, there would be more or less difficulty in the unsupported dies through tendency toward displacement of one member or the other of the pair.

As with other dies shown, the die block and bending punch or upper die are held to the die base and punch plate by fillister head screws and dowel pins. The pressure pad is carried by two fillister head screws whose heads are free to travel in the counterbored holes in the punch plate.

Knock Out for Both Punch and Die

Fig. 331 illustrates a case where knockouts are applied to both punch and die for certain operations in bending. The work is part of a sheet metal hinge appearing when completed as shown at *C*. The blank is seen at *A* and the first bending operation produces an article illustrated at *B*. The piece is made of 0.0625 in. sheet steel, $1\frac{1}{2}$ in. wide.

The first operation tools, Fig. 332, pierce the six holes and cut off the blank from the strip of steel. The stock, after the end has been trimmed off, is fed to the stop *E* which is adjustably secured by two cap screws. After the first cut, the dies work progressively and a blank is pierced and cut off at each stroke of the press, and falls through the open die shoe as cut off. The cutting off punch will be seen to be longer than the small piercing punches so as to sever the piece before the punches come into contact with the stock. As pointed out at another place, this is to prolong the life of the punches.

It is also essential to make the stock guide slot in the stripper no wider than is necessary to allow the stock to slide. As will be noticed, the cutting off punch *G* is cut out at *I* for the purpose of providing room for the machine steel punch plate *J* which, with the cutting off punch, is secured to the punch holder *B* by fillister head screws and dowel pins.

The second operation punch and die, Fig. 333, bend the blank to the form at *B*, Fig. 331. The cast iron die shoe *A* has two hardened tool steel blocks *B* mounted upon it and held by four fillister head screws through the shoe. The forming punch *C*, of hardened steel, is secured by four screws to the cast iron punch holder *D*. The stops *E* locate the blank centrally and sidewise over the die. Spring knockout pins are provided for both the punch and die. The right tension for the knockout spring for the punch can be secured by adjusting the screws *F*, while the knock out spring and pins in the die have means of adjustment through the screws *H* and the nuts *I* and *J*.

The third operation punch and die are illustrated by Fig. 334. The sectional view at *A* shows the simplicity of construction of these tools. The hardened tool steel die block *C* is mounted on a cast iron die shoe and held with screws as is clearly shown. Gage stops *D* locate the work in relation to the V form of the die. The forming punch *F*, which is of necessity very slender and therefore subject to breakage, has to be reinforced without in any way interfering with the die or the work. The way in which this is accomplished is shown at *B*, Fig. 334. The forming punch

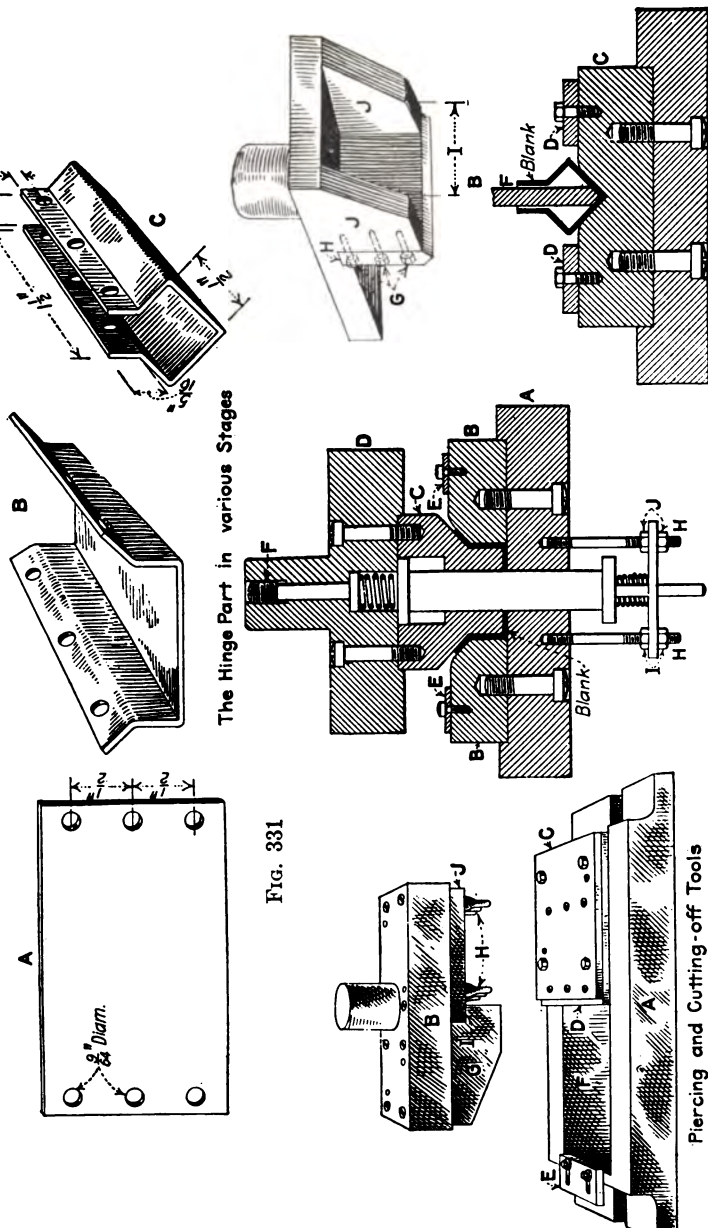


Fig. 331

Fig. 332

Fig. 333

Fig. 334

Figs. 331–334.—Press tools for a sheet steel hinge part

rests in the slot *H* and is secured to the webs *J* of the punch holder by six screws, as indicated by dotted lines *G*. The distance *I* is ample to clear the width of the die block so there is no interference.

By using this method of mounting very thin forming punches the danger of bending or breaking is eliminated, and the replacing of old punches is simplified.

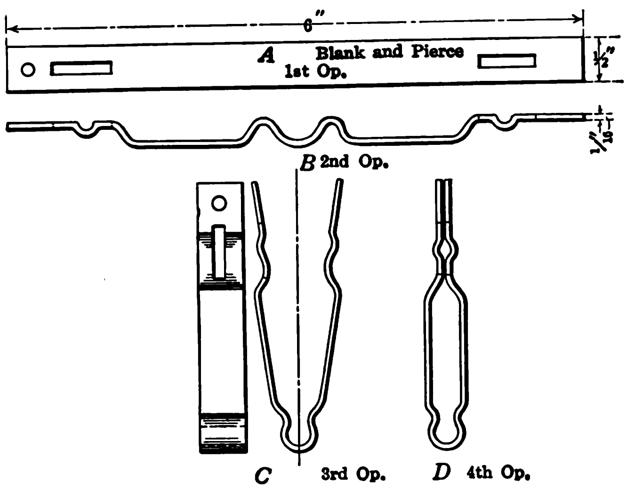


FIG. 335. — Operations in a formed and bent spring clip

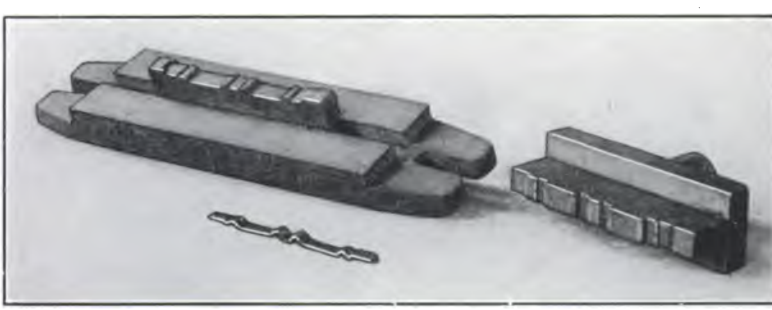


FIG. 336. — The first operation forming tools

FLOATING WORK SUPPORTS

The principle shown in Fig. 334 of striking a blank in the middle for bending up the ends hair pin fashion is often applied with first bending operations as well as with the second or forming operation illustrated in that view. And where a blank is so bent to a U form with arms that require closing together, as with, say, some form of spring clip, the work may at times be supported upon a type of floating holder that allows the piece to be carried down into the die and, upon its release from the upper die or punch, to be lifted clear from the dies for removal by the operator.

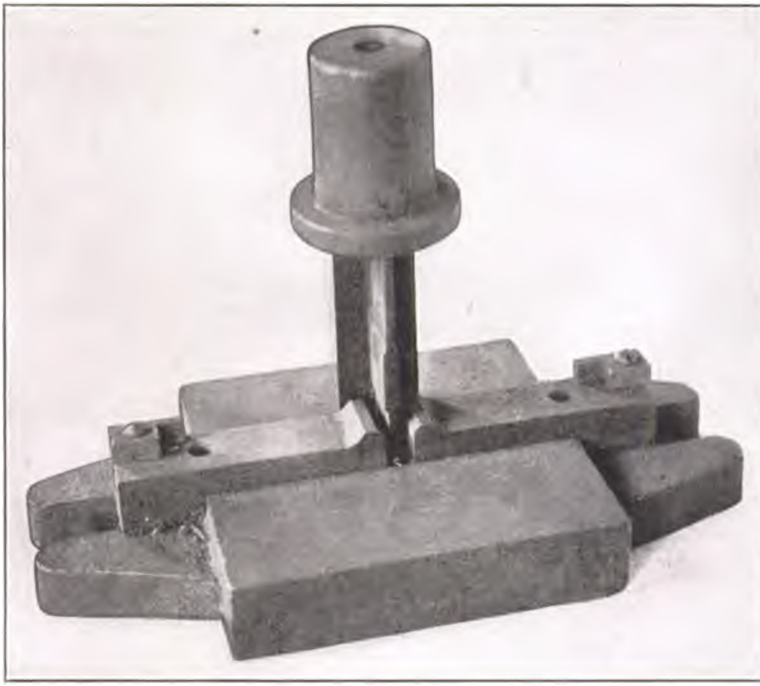


FIG. 337. — The bending dies for the spring clip

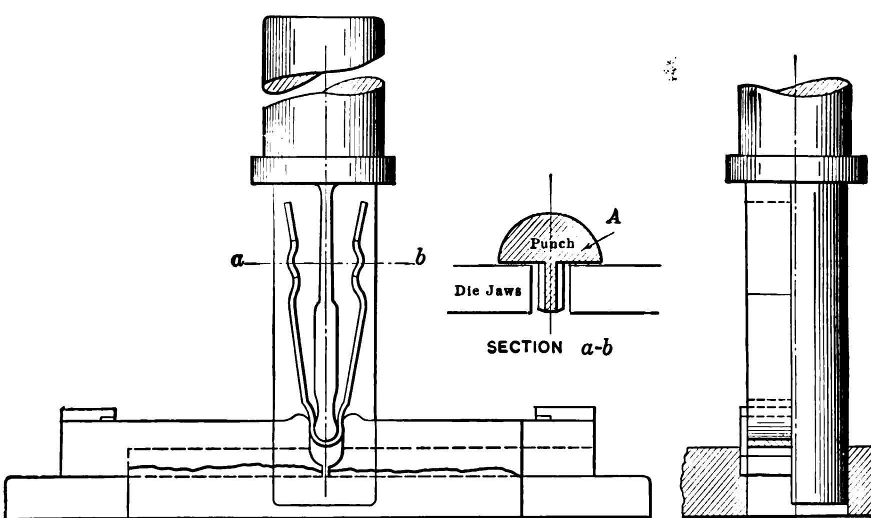


FIG. 338. — The bending die construction

A case in point is illustrated by the bent and formed spring pin, Fig. 335, which is manufactured from $\frac{1}{16}$-in. steel, $\frac{1}{2}$ in. wide. This steel piece is first pierced and cut off to length in dies like those in Fig. 156, Chapter V. It is then placed in the forming dies, Fig. 336, where the central loop and the various other bends are made crosswise of the stock. These dies are simply upper and lower shoes of cast iron with hardened steel forming blocks inserted in their faces and secured by fillister head screws and dowels. The die blocks are provided with end shoulders to form a locating device for stopping the end of the blank from passing over the end of the die. One down stroke of the press forms the blank to the corrugated slope at *B*, Fig. 335. It is then ready for the bending dies, Figs. 337 and 338.

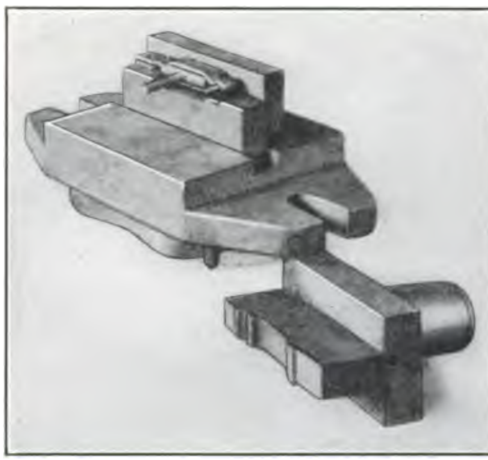


Fig. 339. — The finish forming dies

The latter drawing shows the work in place and bent up by the downward pressure of the punch. The punch is a T-shaped tool with a narrow portion crosswise of the end to produce the bending action at the middle of the work; the back of the punch is virtually reinforced for rigidity and strength by the portion of the body which has not been cut away in forming the bending section. This leaves the cross section of the punch as at *A*, Fig. 338, with a full half circle which is used as a guide in the descent of the punch into the die, the letter being bored at the center to form a bearing for the back of the cylindrical punch surface.

The die blocks are in the form of jaws with well rounded upper corners and with stop gages at each end for centering the work. As the punch descends and forces the work between these jaws, the action of the two elements, punch and jaws, is to bend the work to a small circle in the middle corresponding to the similar form on the end of the punch. This circular curve merges into the concave curve directly above on the punch and the die jaws are so shaped as to conform to this and give a cleanly bent piece, like *C*, Fig. 335. The ends of the work spring apart as the piece is removed from the punch on its up stroke and a fourth operation is used to close the ends as at *D*, in the same engraving.

It is here that the carrier is provided to receive the work from the operator, allow it to be forced down into the dies, and finally, return it to clear position for removal.

The dies are represented by Figs. 339 and 340. Referring to the latter view, the work is shown at D, in the dies, with the dies closed upon it. It is held, however, upon a small arbor or pin E, which holds the size of the loop at the end of the work against any tendency for it to close flat when the dies are pressed against it. This pin is carried in a holder F which is mounted upon a spring plunger G placed vertically in the back of the die shoe so that it can move freely when released by the dies.

The operator places the work over this pin and the upper die, in descending, carries the work and the support F down until the bend is

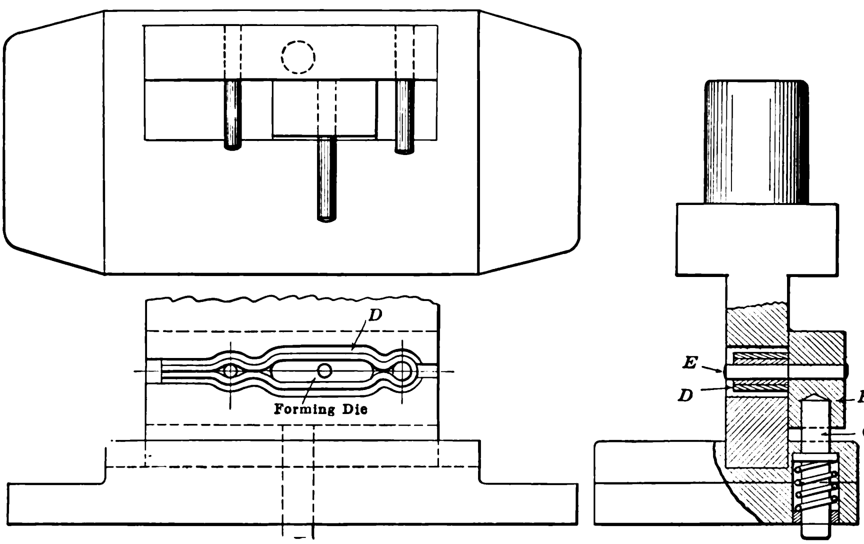


Fig. 340. — The finish forming dies

completed by the squeezing of the piece between the dies, then on the up stroke, the spring actuated device lifts the work clear and it is removed from the end of the short pin E.

While the dies here, as in previous illustrations, are of tool steel, hardened, there are various examples of bending and forming tools where all parts are of machine steel, which very often is not even case hardened. This is, of course, with dies used on small lots of work or where the general conditions of operation are such as to impose little wear upon their surfaces.

A Flat Forming or Curling Job

The tools, Figs. 341 to 345 inclusive, are for making the piece shown in Fig. 342. This is a triangular part, blanked and formed from $\frac{1}{32}$ in. stock. It is curled or formed at the edges and one end of each curl is closed by pinching under a punch.

The blanking is done in the tools shown in Fig. 341. These are of the

progressive order and before the piece is blanked from the strip it is stamped as indicated, on the face. The progressive tools need little in the way of description but there is one feature to which attention should be called:

These blanked parts are to be curled or formed up at the ends as pointed out, and to assure this operation being performed satisfactorily, the edges where the curl is required are bent very slightly, as indicated by

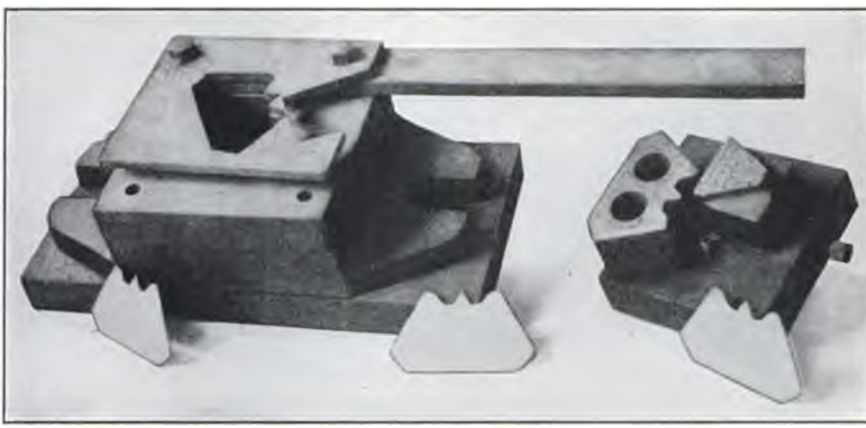


FIG. 341. — Progressive stamping and blanking dies

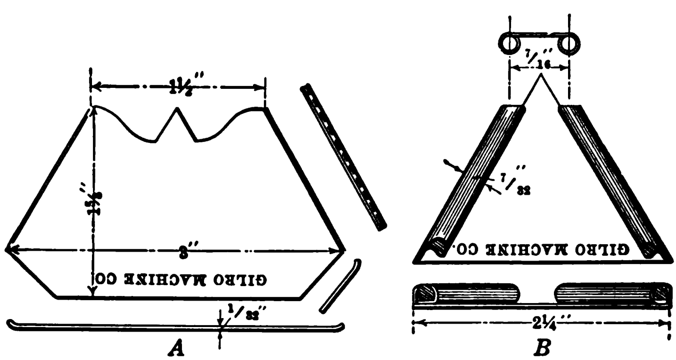


FIG. 342. — The work before and after curling and forming

the sketch at *A*, Fig. 342. Without this starting edge there would be no assurance that the curl would be started correctly in the second operation dies. So the blanking tools, Fig. 341, are made with the edge slightly chamfered off from the blanking punch, as will be plainly seen upon inspection of that engraving. At first thought it might be expected that there would be difficulty in cutting out the blank with a punch so chamfered on its corners, but in practice no such trouble has arisen. The work comes out of the dies with a clean edge slightly bent up as desired. Probably

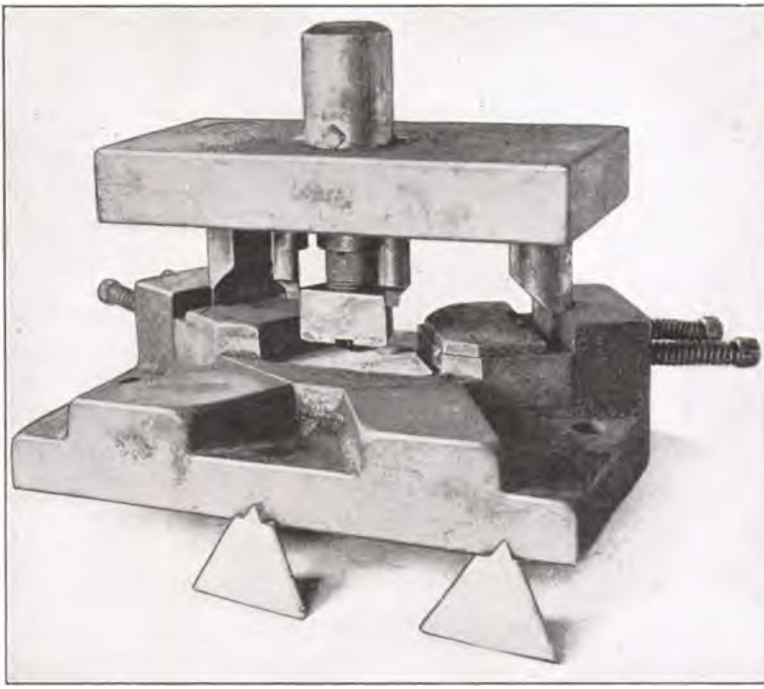


FIG. 343. — The end curling die

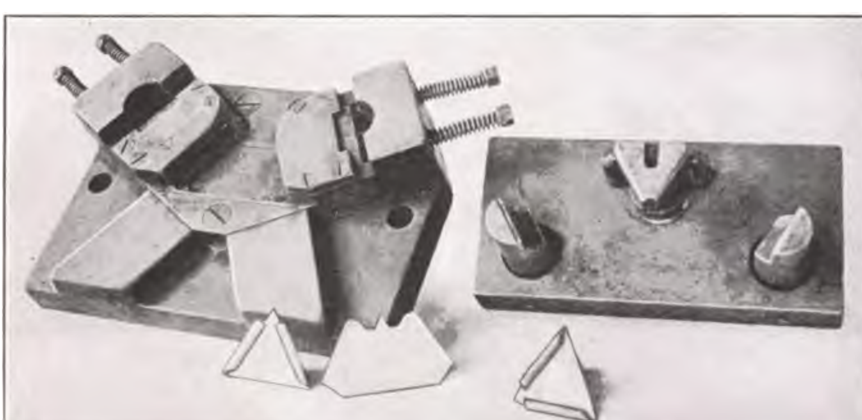


FIG. 344. — The end curling die

because the metal is of such light gage, the beveled edge of the punch acts to "pinch off" the material after it has turned the edge as required.

When the blank is placed in the forming or curling tools, Figs. 343 to 345, it lies flat in the die as seen in the latter view, and the edges are upturned so that when the forming slides or jaws, *J* are forced forward, the metal blank naturally follows up and around the inside of the concaved jaw ends and rolls into a neat curve.

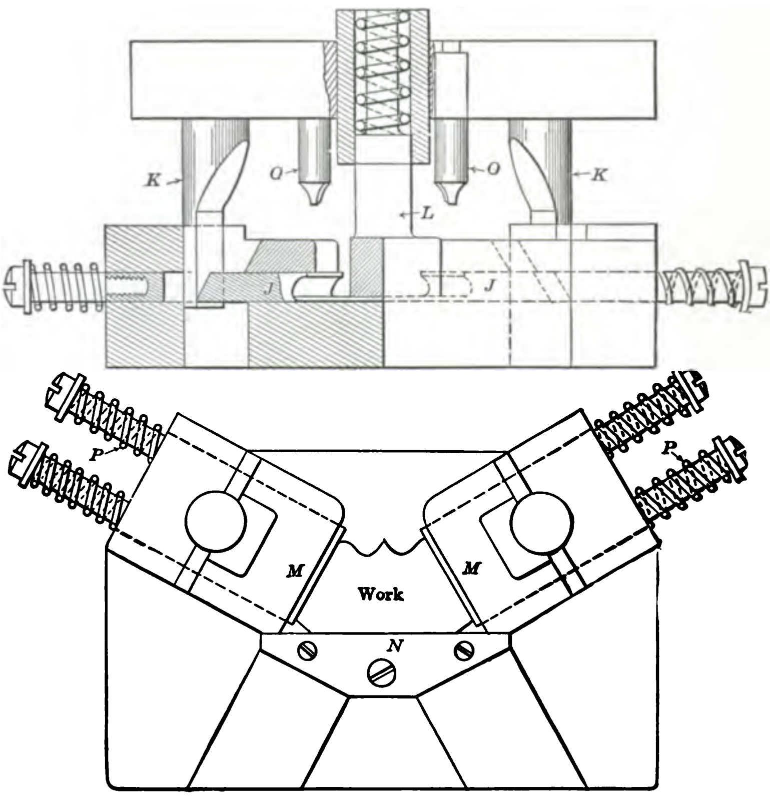


Fig. 345. — Dies shown in Fig. 344

The jaws *J* are actuated by the plungers *K* carried by the punch holder. They are provided with wedge shaped surfaces near their lower ends, and these inclines, after the plunger ends are well down and supported in their guides in the die base, force the sliding jaws *J* forward to do their work. The punch *L* is a spring plunger with a large head which serves to hold the blank in position in the die during the forming operation. The blank rests between the two angular faces of the jaw housings at *M* and a tool steel block fitted in at *N*. At the side of the plunger *L* there are two small punches *O* which are adapted to strike the top of the curl on the work and pinch one end down to the form shown in Fig. 342, *B*. The spring plunger

L has sufficient movement in its holder to allow the latter to descend for some distance, after the plunger starts, to hold the blank, and during this continued travel the work is curled up and the ends flattened.

On the up stroke of the punch holder, the sliding jaws *J* are withdrawn from the work by the action of the springs *P* and the spring plunger *L* releases the finished piece.

The jaws *J* which do the forming are of tool steel, hardened. They slide in obliquely planed seats in the die shoe and are held in position by machine steel cover plates. The beveled plungers *K* which operate the jaws are also of tool steel, hardened.

Spring Forming with Sliding Jaw Dies

These dies with sliding jaws and similar devices for bending up a blank or for forming the ends into the desired form are often known as compound bending or forming tools to distinguish them from the more commonly

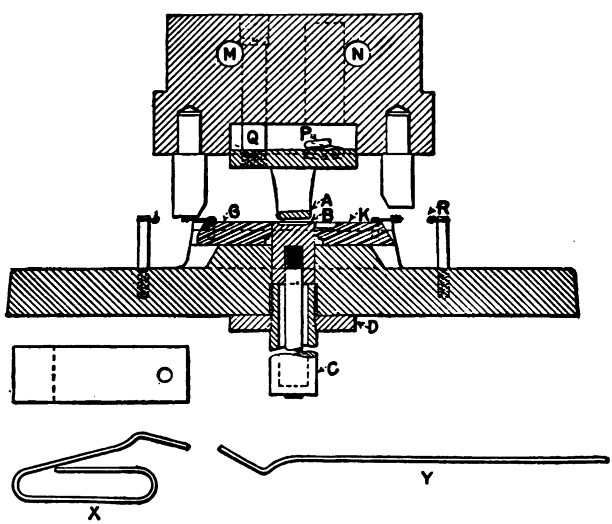


Fig. 346. — Spring forming die

used plain die with simple bending punch and fixed die jaws. The compound type is frequently employed for such operations as spring bending or forming and an example of this class of work is presented in Fig. 346 herewith.

This illustration represents the cross section of a die for performing the last operation on the flat spring shown at *X*, while *Y* shows the spring as it comes to the die. The operation of the die is as follows: The work is placed on the lower part of the die between small gage pins, which are not shown. The press is tripped; and as the upper part of the die or the punch

descends, the ends of the spring are turned up into vertical position by the L-shaped piece *A* forcing the steel down into the groove cut through the square head plunger *B*. As the upper half of the die continues to descend, the plunger *B* is carried down against the action of a coil spring within the barrel *C*. The square steel plate *D* is threaded to fit the thread on *C* and is fastened to the cast iron base of the die. The plunger *B* is forced nearly down to the top of the barrel *C* when the wedge engages the slide *G*, which is forced toward the center of the die and thus starts to form that end of the work around *A*. As the downward motion continues, the other wedge engages the slide *K* and thus folds over the other end of the work.

While this part of the operation is being done, *B* is stationary and *A* is being forced upward against two heavy coil springs, only one of which is shown at *P*. These springs are located in diagonally opposite corners of the rectangular upper end of the steel part *A*. In the other two corners are hold-up bolts that also act as guide pins. One of these is shown at *Q*. As the head of the press ascends, the slides *G* and *K* are pulled back against stops by the coil springs *R* as shown. There are two of these springs on each slide, arranged in the form of a V, to pull on each slide. Bolts pass through the holes *M* and *N* to fasten the upper half of the die to the ram of the press.

Progressive Type of Dies for Bending

As already noted, in connection with the dies in Fig. 341, bending and forming dies are arranged on the progressive order to allow a series of operations to be accomplished simultaneously in a set of tools. Such operations may include piercing, bending, and blanking; or piercing, cutting off, and curling; etc. Some illustrations follow, these being shown in connection with some simple bending work on parts used in conjunction with the pieces made by the progressive type of dies.

The handle *A*, Fig. 347, consists of three parts, the wire grip, the wire loop, and the strap for attaching the handle to a box. Beginning with the wire grip there are three essential operations; cutting the blank from the rod, bending the blank to shape for the hand hole, and curling the ends for the attachment of the link.

The sketch, Fig. 348, is a diagram of the press attachment used for the first two operations. The machine used was not a satisfactory one for the purpose but no long stroke press was available so this attachment was devised. The device fastens to the front of the press and is operated by the balance arm; since but little power is required it works satisfactorily. The fixture requires little explanation. As part *A* descends it comes in contact with the parts *BB*, causing them to swing about their pivots *CC*, forcing the blank to take the shape of the form *E*, also shown at *F*. The return stroke of the press withdraws *BB* allowing the removal of the finished

piece and the insertion of a blank ready for the operation to be repeated. Following the bending operation, the ends are curled to receive the link *G*, and lastly closed over the link as shown at *H*.

The method of curling the ends, which are completed in two operations, is illustrated by Figs. 349 and 350. As can be seen in Fig. 349, the handle is placed flat in the die, the ends against a stop while a spring clamp holds it in place. As the punch descends it forces the handle into the grooves in the die thus giving it the required shape, the bend being made, of course, far enough from the ends to leave sufficient material to complete the loop. Following this operation, the link is placed in position and the loop closed with the tools in Fig. 350.

The making of the link or wire loop consists of essentially three operations: cutting off the blank, bending the ends, and curling to complete the

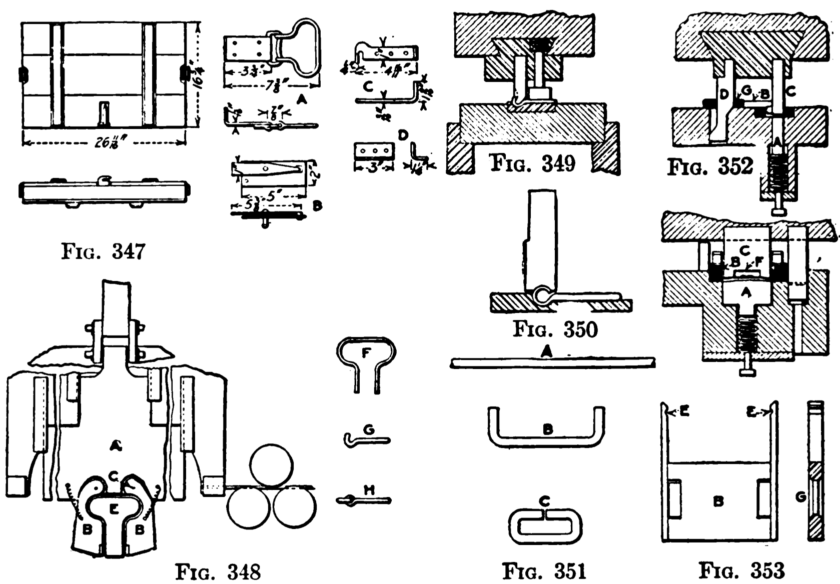


FIG. 347 FIG. 348 FIG. 349 FIG. 350 FIG. 351 FIG. 352 FIG. 353

FIGS. 347–353. — Ammunition box and hardware and the tools used

loop. These operations are shown in Fig. 351. The rod is sheared to the proper length by a simple operation that requires no explanation. Following shearing, the blank passes to a double punch and die, Fig. 352, where the ends are bent to the form shown at *B*, Fig. 351, thence to the second part of the machine where it is again bent or curled at *C*, thus joining the ends and completing the loop.

The first bending operation leaves the link clinging to the punch or die, and to make certain of its removal and transfer to the next operation, with safety to the operator, the knockout and transfer devices shown at *A* and *B*, Fig. 352 are utilized. The knockout is very simple and can be

readily understood from the sketch; the transfer device, however, requires a brief explanation:

During the forming of the blank the two wedge-shaped pieces D act on the tapered portion G of the transfer device B, moving it toward the punch until the notches E, Fig. 353, grip the link. The return stroke of the press causes the device to move in the opposite direction sufficiently to bring the link into position for the final operation which is performed by the punch F, Fig. 352. The action of the punch F is similar to that of punch C and simply bends the link in the center, joining the two ends and completing the loop.

Making the Strap

The strap which fastens the handle to the box is next in order and its manufacture consists of five operations; punching the screw holes, blanking, preliminary curling to receive the link, final curling, and bending the angle at the end. The stock from which these straps are made, is 2 by $\frac{1}{16}$-

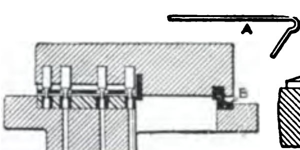


Fig. 354

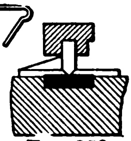
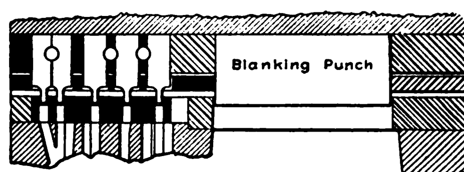
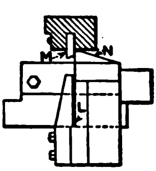
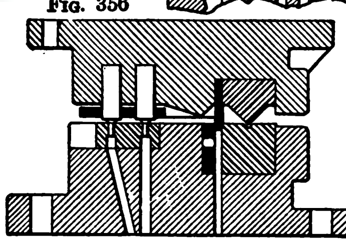


Fig. 356







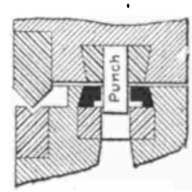


Fig. 355 Fig. 357 Fig. 358

Figs. 354–358. — Ammunition box and hardware and the tools used

in. steel. The first press performs three operations in the order named. At commencement of this series of operations, the strip of steel is pushed under the stripper in Fig. 354, to a point where the end will just be sheared, and punching and shearing then take place. The end of the strip is then brought up against the stop just beyond the curling die and the operations take place in the order already indicated. After the curling operation, the strap is left in the shape at A, ready for the closing of the loop. The shape and position of the curling dies are shown at B. Immediately following this operation, the curling is completed, joining the loop and strap, and the end of the strap is then bent at a right angle for fastening to the bottom of the box.

Fig. 355 shows the fixture for the final bending operation which connects

the strap, loop, and handle. Fig. 356 shows the tools for bending the angle on the end of the strap, these being placed in the same press with those for forming the strap. The fixture in Fig. 355 is used as follows: The long end of the strap is placed upright in the slot *L* and when the punch *M* descends it causes the curved end to bend until it lies close to the body of the strap, thus forming the loop for enclosing the link. During this operation, the loop is held in place by the handle which is laid back over *N*. Bending for the angle requires no explanation, this being performed at the same time as the final curling.

The small angle *D*, Fig. 347, serves to fasten the side of the box securely to the bottom and is made in four operations. These are: punching for

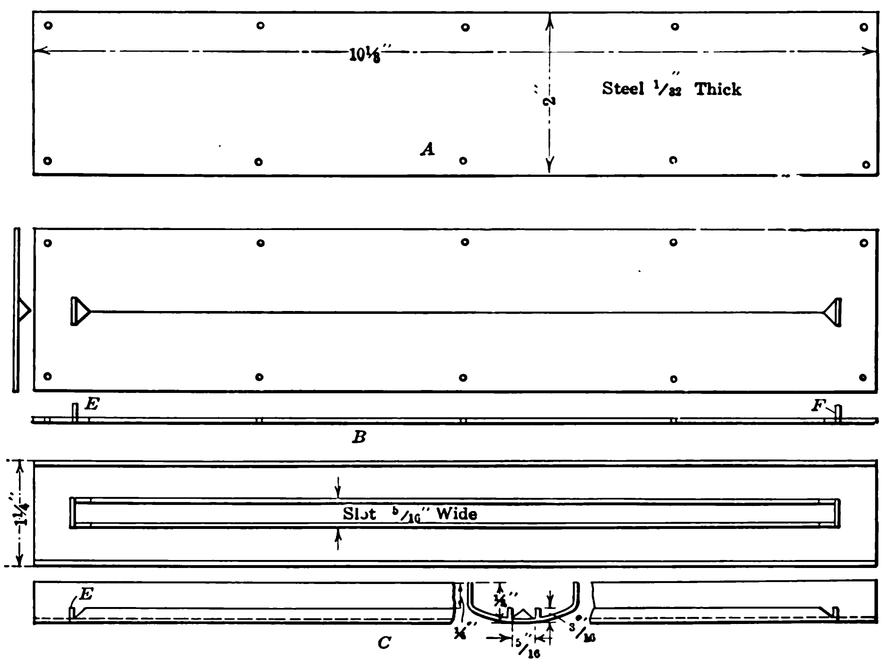


Fig. 359. — Sequence of operation in blanking, slitting and slotting

screw holes, shearing, countersinking, and bending. The punching, shearing and bending operations are similar to those already shown for the handle strap and the countersinking is performed in an ordinary drill press. Fig. 357 illustrates the arrangement of the tools in the press for these operations. They are simple and self-explanatory.

The latching device for the cover consists of the latch on the cover *B*, Fig. 347, and a formed hook attached to the bottom of the box. The construction of the latch requires only very simple operations of punching and shearing for the spring plate, while the portion which engages the

hook is forged. The making of the spring plate and latch requires no tools of special interest and need not be described.

The hook used in connection with the latching device is the heaviest work on any of these parts and there are four operations: Punching, blanking, countersinking, and bending to form the angle. The finished hook is shown at *C*, Fig. 347. The punching, blanking, and bending operations are, of course, all performed in one operation in a press and the countersinking in a drilling machine. Fig. 358 shows the arrangement of the tools, including the die for the angle, which is formed at the same time.

Application of the Slitting Principle

In connection with the use of bending and forming dies there is now and then a piece of work where an unusual operation is required before the real work of forming can be accomplished. This preparatory operation, as it might be called, consists in cutting a slit with a pair of dies to

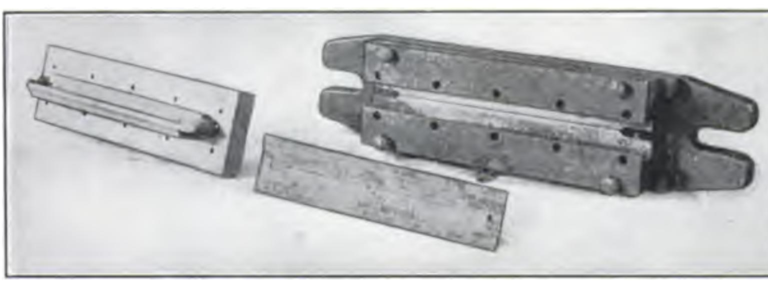


Fig. 360. — A slitting die

provide two edges for folding or bending back as in forming a channel or similar opening in a sheet metal member. A case in point is herewith illustrated by the sketches in Fig. 359 where *C* is a machine part formed up to a shallow channel-shaped piece with a slot $\frac{5}{16}$ in. wide nearly the full length.

The blank for this part is shown at *A* with a series of holes pierced around the edge. At *B* is shown the piece with the slit cut along the center line and two small triangular tips formed up at the end of the slit.

The slitting tools are shown by Figs. 360 and 361, and referring to the latter view, the slitting punch proper will be seen at *D* and the piercing and forming punches for the triangular points *E* are located at *G*. These latter punches are made with half-inch round shanks fitted into holes bored in the punch holder. Their sharp V edges are abutted against the ends of the slitting punch *D* and their ends project $\frac{1}{8}$ in. below the edge of that punch to perform their work before the slit is cut.

Referring to the sectional view to the left, the slitting die will be seen

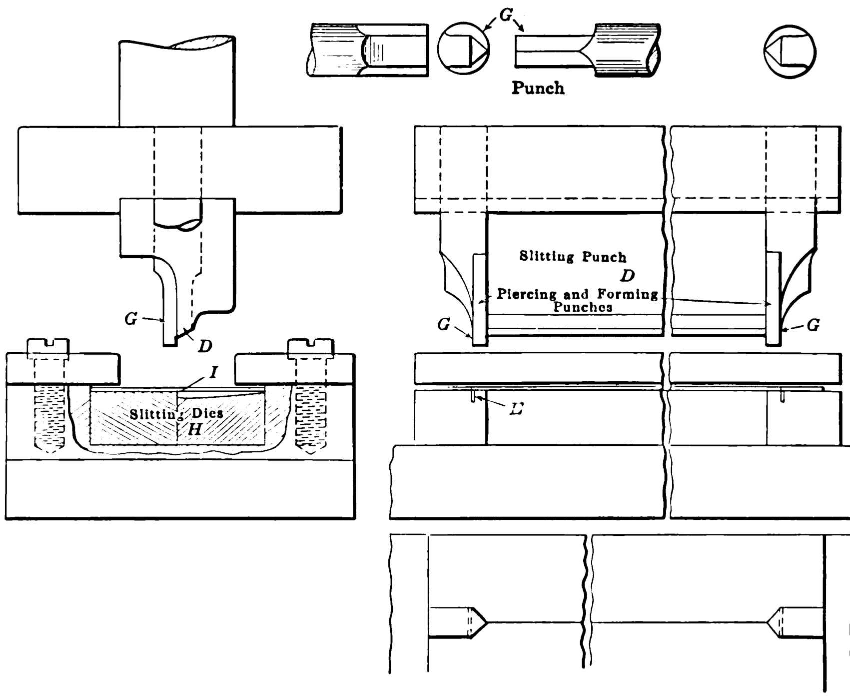


FIG. 361. — Slitting dies

FIG. 362. — Forming tools that follow the slitting die

at *H*. It is made in two sections, divided along the longitudinal center line, and one side is relieved for a depth of $\frac{1}{16}$ in. as indicated to allow the slitting punch to shear the material past the die edge formed at the shoulder *I*. The slitting punch itself is $\frac{3}{16}$ in. thick back of the cutting edge and has a body thickness of $1\frac{1}{4}$ in. for attachment to the punch holder where it is secured by fillister head screws and dowel pins. The punches and die sections are of tool steel, hardened.

The forming tools are seen in Figs. 362 and 363 and in the former engraving the finished work is also shown. The construction of the tools will be understood upon referring to the section in Fig. 363. The lower die *I* is of tool steel secured by fillister head screws and dowel pins in a seat in the shoe or base. The upper die *J* is similarly fixed in the punch holder. The lower die is fitted with a tongue-shaped member *K* which serves as a punch to bend up the material along the edges of the slit, and similarly the punch *I* is grooved at *L* to form a die for this forming operation. Thus, as the blank is forced down into the main forming die *I* its sides are folded up into the channel form and as it nears the bottom of the die the slitted portion is bent up and formed by the punch section *K* and die slot *L*.

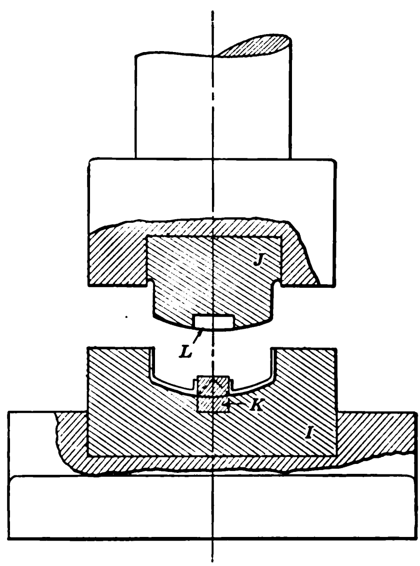


FIG. 363. — End view of forming die

The blank is located on the die by the gage pins shown in the photograph, Fig. 362.

A Sectional Construction

The coin register part shown in Fig. 364 is produced from 0.035-in. stock by the tools in Figs. 365 and 366. These are of interest because of the unusual form of the piece and because of the sectional construction of the dies. The blanking tools are represented by Fig. 365.

They consist of the built-up die and punch seen side by side, where the sections of the punch are particularly clear. The die is similarly constructed but the individual parts are obscured by the stripper. The special features of the work are the right-angle bends at each end of the base and the curved deflectors in front which are formed up to a flaring curve diverging from the center outwardly. The flat base is also curved along its edge as indicated in the drawing and the sections there reproduced give the slope of the curves at various points.

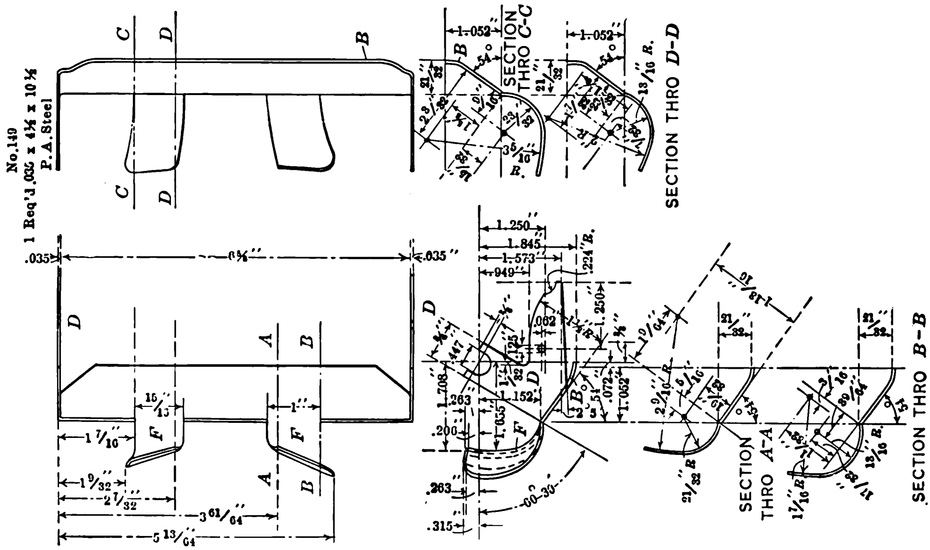


FIG. 364. — An unusual shape to be formed

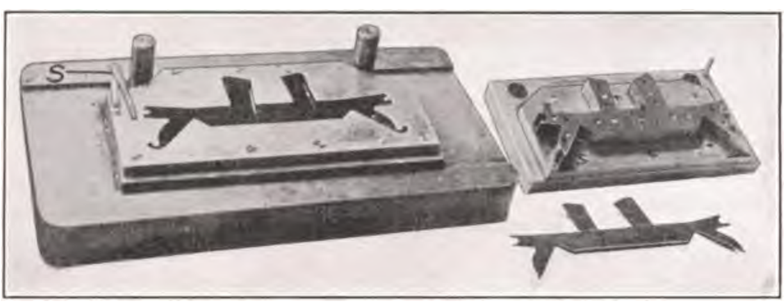


FIG. 365. — Sectional blanking tools

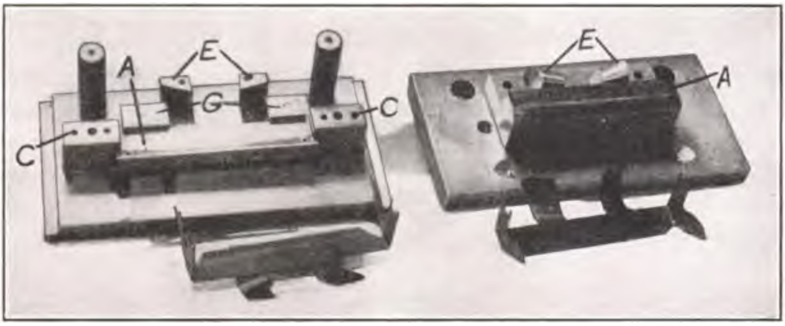


FIG. 366. — The bending and forming dies

The blank is placed for forming, on the pressure pad and knock out A, Fig. 366, which has a locating ledge at the front with a curved face leading up to it to produce the curve along the edge of the work at B (Fig. 364). The end forming die blocks are at CC for bending up the wings of the blank at DD (Fig. 364). At the back of the die are secured two blocks EE for forming up the curved deflectors FF (Fig. 364). The back of the blank rests against stops GG when the work is placed in the dies. As the upper die descends the punch block A' forces the blank down into the face of the pressure pad A and continuing downward, the ends of block A' cause the ends of the work to be bent up at right angles against the die blocks CC. At the same time the curved end punch blocks $E'E'$, form the ears F against the die blocks E at the back, and the bent up lip along the front edge of the blank at B is formed between the bottom of punch block A' and the corresponding curved surface at A.

When the upper die or punch head ascends, the pressure pad and ejector A follow the punch upward and lift the formed work out of the dies.

All parts in the way of punch and die members are of tool steel, hardened, and the punch holder and die shoe are of machine steel. The bolster for the blanking die sections is a large casting planed out lengthwise to form a seat for the various blocks which made up the die as a whole. The stock stop for the material for the blank is of the trigger type and is shown at S, Fig. 365. There are two guide pins in this die base for alining the punch holder, and similarly two pins are used in the forming dies, Fig. 366.

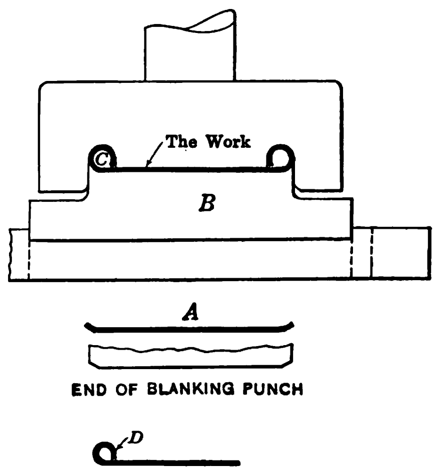


Fig. 367. — Curling operation

A Word About Curling

In several places certain operations in the line of curling have been shown and a final word may be added at the close of this chapter in reference to this process. It has been pointed out in connection with the operations shown in Fig. 342 that the end of the blank should be made with a slight initial curl to assure its finishing properly when passed through the curling dies. The punch for blanking should therefore be made with the corners taken off to leave a round bend on the blank as at A, Fig. 367, so

that in the curling dies *B* the ends of the work will follow the concave die form and complete the circle as at *C*.

If the end of the blank is cut off square as at *D* the subsequent curl will be in the form shown at *C* with the end brought down to the body of the blank at *D* but not curled in as it should be. This is overcome by making the blanking punch as stated, with the corners rounded as at *A*.

CHAPTER XI

BENDING, FORMING, AND OTHER DIES APPLIED TO SPECIFIC LINES OF WORK

The bending and forming tools illustrated in this chapter are presented to show particular applications of such equipment in conjunction with other classes of dies, such as blanking, piercing, and other tools, for performing in sequence the operations necessary in manufacturing certain parts for typewriters, calculating machines, coin registers, etc. It is believed that this method of presentation cannot fail to be of service as something of a guide to those laying out and constructing sets of dies for work of somewhat similar character.

The arrangement of this chapter also gives a further opportunity for illustrating a variety of press tools which, while falling within some one or more of the general classes already described under preceding chapter heads, have, nevertheless, certain features that are peculiar to themselves and justify a description in the present section of this book.

Blanking, Piercing, and Forming Tools for Typewriter Work

The tools that follow are used in the manufacture of a sheet metal member, known as a universal bar, for the Noiseless typewriter.

This part is $9\frac{3}{8}$ in. long and is bent up to a quarter circle of $5\frac{3}{8}$-in. radius, as shown in Fig. 368. It has three lugs or arms projecting from the lower edge, which are offset in the blanks and then bent around at right angles to the body of the bar itself. It is made from sheet-steel stock 0.040 in. thick, and one piece is required for each typewriter.

Figs. 369 and 370 illustrate the blanking tools used in the production of these sheet-metal parts. The die is of simple construction, and the punch is of a form requiring little explanation in detail. However, the length in proportion to the width of the projecting portions that form the lugs on the blanks is such that a considerable degree of care and judgment was necessary in machining and hardening these tools in order to prevent a degree of deformation which would make the punch work improperly in the die. Both punch and die are mounted upon heavy blocks, the bolster for the die being of the standard form used in the factory for a large share of the press tools.

The proportions of the die proper will be seen from Fig. 369, which

shows the layout as indicated by the opening in the stripper and also the width of the stock guide slot in the underside of the stripper. The dotted lines in the top of the plate show that the width of the guide is sufficient to admit stock wide enough for two rows of blanks, so that the material is reversed for the second passage through the press and there is very little waste along the edges of the strip of stock or between the projecting lugs.

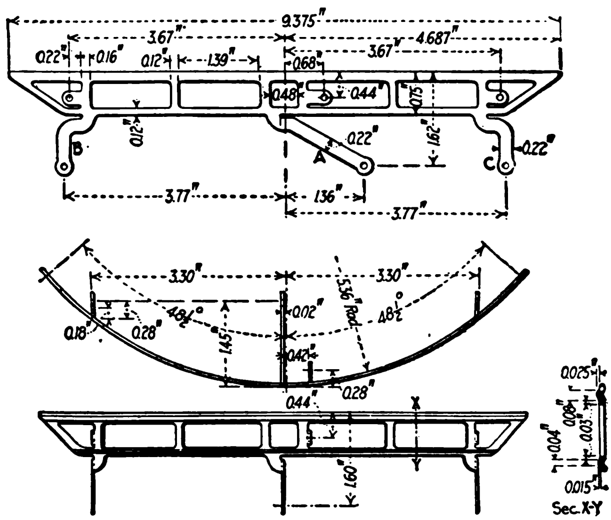


FIG. 368. — Details of universal bar for typewriter

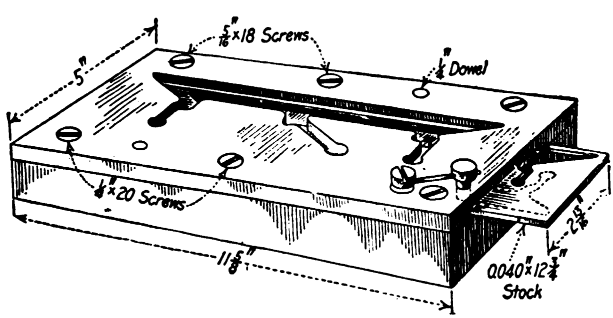


FIG. 369. — The blanking die

The second die, Fig. 371, is used for punching out the seven openings. In this process a greater portion of the material is cut away. The work is shown at the front of the die. It will be noticed that there are also six round pierced holes in the lugs. As a matter of fact, this piercing operation is performed in a subsequent process, the blank being shown here in this condition to indicate its appearance before twisting of the lugs occurs.

These dies, like the blanking tools shown, are simple in construction,

although they have been laid out and finished with great care to assure satisfactory operation under the punch press. In working material of this thickness, where such narrow portions of the stock are left as are indicated in the illustration, it is important that the material shall have no opportunity for creeping under the punching action of the tools. Otherwise, the edges become deformed, the inner openings formed by punching out the stock become twisted, and the job is generally unsatisfactory.

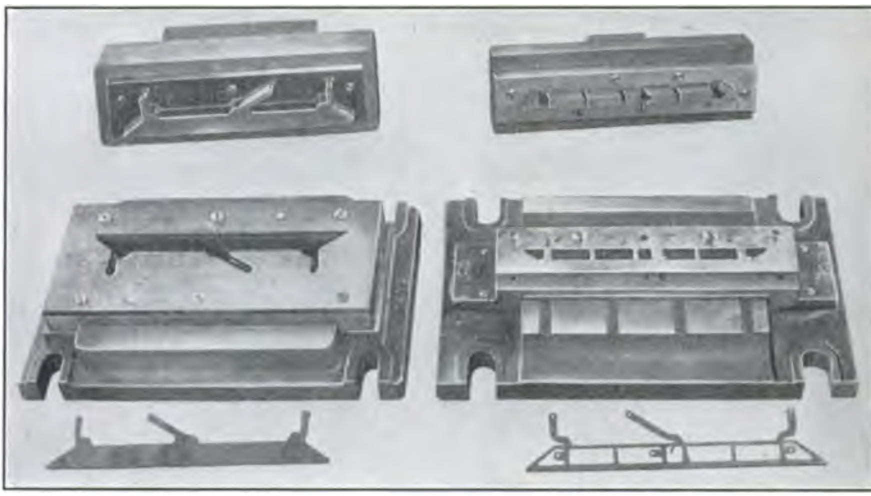


Fig. 370. — The blanking tools Fig. 371. — Dies for second operation

Piercing Six Holes at Once

Referring to Fig. 372, the press tools at the left perform the operation of piercing the six holes in the blank. Here, a sectional construction is used, as indicated. The work is nested under the stripper plate, against suitable end stops and back stops, and is thus retained against movement during the downstroke of the punch. The latter has a block that is provided with corner posts, thus making a pillar-die construction. As will be seen, the small piercing punches are all carried in sockets sufficiently large to assure stability of the punches and prevent their deflection under the action of piercing this 0.040-in. piece of stock.

Each of the punch members as shown is fastened securely to the block by fillister head screws and an adequate number of dowels, while the holders for the piercing punches are located outside of the punches proper in holes laid out, and accurately indicated and bored in correct positions on the face plate of a lathe.

The tools at the center in Fig. 372 are for forming up the blank to the arc of a circle and bending down the middle lug or arm nearly halfway to

its right angle position to the body proper. For this operation the work is nested against a stop at one end. The punch in descending with its curved lower contact face forms the blank down into the curved seat on the top of the die, the projecting hub or pilot at the middle of the punch engaging with the square opening at the middle of the length of the work, thus preventing the work from traveling either to the right or the left.

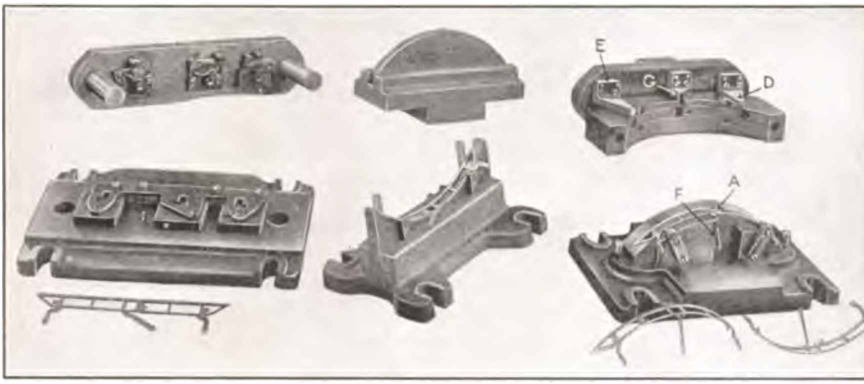


FIG. 372. — Dies for forming the universal bar

Looking closely at Fig. 372, it will be seen that there are stop lugs at both the back and the front of the die to make of the latter a suitable nest in which the straight blank will rest securely during the downstroke of the press, under which it is transformed into the curved article.

At this same setting the two grooves, or beads, running longitudinally the full length of the work are formed up to stiffen the job so that, when bent to the arc of the circle, there will be little likelihood of its being twisted or deflected in action. The stiffening ribs, although shallow, are sufficiently deep to add materially to the strength of the parts and greatly increase its resistance to any forces tending to open the arc out toward a straight line or to twist the curved portion about its major axis. The use of ribs in this way forms a convenient method of strengthening sheet-metal work without increasing the weight and adds practically nothing to the cost of manufacture, as the forming of the grooves, which also form the beads, or ribs, on the opposite side, is done at the same stroke of the press as the body of the piece is bent to the arc of the circle and the central lug bent halfway down.

The tools at the right, Fig. 372, are the most interesting of the group in this view, and details will be seen in Fig. 373. It will be noticed that here the work is nested upon the convex face of the lower die, and on this die block it rests between a pair of pins at the back and two adjustable stop screws at the front. Midway of the width of the die will be seen a

vertical offset portion *F* that forms the bending corner over which the middle lug *A*, Fig. 368, is bent around to a true right angle to the tangent line to the universal bar. The lugs at either end, *B* and *C*, Fig. 368, are bent down to a position parallel to the central lug *A* by the two punch members attached at the right- and left-hand sides of the punch block.

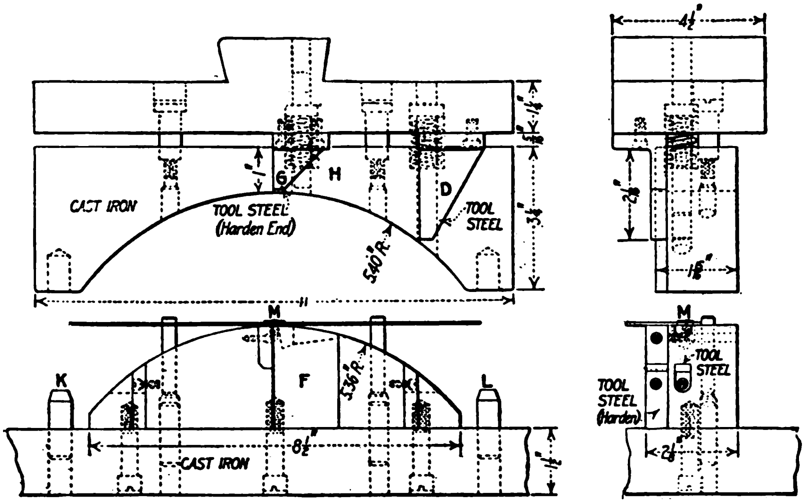


FIG. 373. — Forming die for universal bar

Referring again to Fig. 372, it will be seen that the concave block *F* is arranged to act as a pressure pad to hold the blank temporarily during the descent of the press ram, while the punch members *D*, *E*, and *G* fold down the three ears or lugs to the right-angle position. The movement necessary after the pressure block seizes the work is about $\frac{3}{8}$ in., and this is allowed for by the compression springs seated between the block *H* and the main punch block, as shown in Fig. 373.

It should be noticed that on the downstroke of the press the first thing that happens is for this pressure pad *H* to drop over the pilot pins *KL*, so that here again a subpress form of action is obtained in that at the moment of operating upon the blank the punch and die are piloted and guided together by the pillars, or pins, at either end.

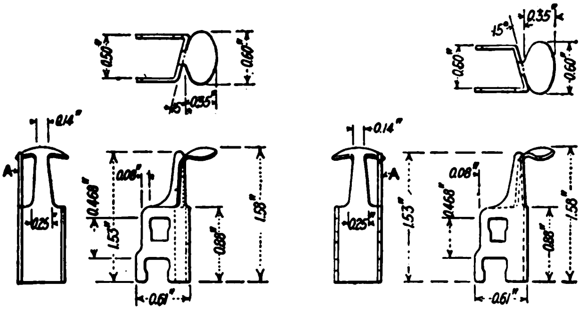
The two punch members *D* and *E*, only one of which is shown in Fig. 373, but both of which are clearly visible in Fig. 372, are in the form of angles with stiff uprights and bases, the latter having two substantial screws and a pair of dowels, by which each part is secured to the punch block.

Similarly, the central bending punch *G*, Fig. 373, is made with a right-angle base and secured by a pair of screws and dowels. This construction enables the part to be fitted up to the work conveniently and to be replaced in case any part should wear out or give way.

The position of the work endwise upon the lower blank when nested for the downward stroke of the press is positively secured against possible end thrust in either direction, due to the lateral pressure of the bending punches *D* and *E* by the pilot *M*. Upon the upstroke of the press the work is prevented from lifting with the die, due to the binding pressure between the inner faces of the bending punches *D* and *E* by a shedder operating between these punches and acting downward upon the work and holding it upon the convex upper base of the lower die.

Operations on the Margin Stop

The margin stop on the same typewriter is made in the form illustrated in Figs. 374 and 375, which show both the right- and left-hand stops. It will be seen from the drawing that this piece is of sheet stock formed up to box shape with a clip at the top, by which it may be lifted and moved



Figs. 374–375. — The two margin stops

along from one notch to another on the stop bar. These pieces have an opposite working side for the right- and the left-hand stop respectively, and for the projecting lugs at *A*, which constitute the stop proper and which engage the corresponding member on the carriage, thus determining the length of the travel of the carriage in either direction. The material for these stops is sheet steel, 0.040 in. thick, and the size of the blank punched out prior to bending is approximately 2 in. wide by 2¼ in. long.

The first operation in the punch press is performed with the tools shown in Fig. 376, illustrating the proportions of the punch and die with which the notches at the top and the bottom of the stops are cut out, and a rectangular hole is pierced near one edge. These openings are plainly seen in the blanks at the front of the strip of stock lying near the die.

Blanking Die Arranged to Save Stock

It will be noticed upon examination of this scrap metal that the stock is passed through the die twice, it being reversed for the second run, so that the blank which is considerably narrower at the top than at the bottom,

is shown reversed on the second run of the material through the dies and points the other way from its position in the first run. This means that very little material is wasted between adjacent blanks, as compared with the waste that would occur if the material was run through only once.

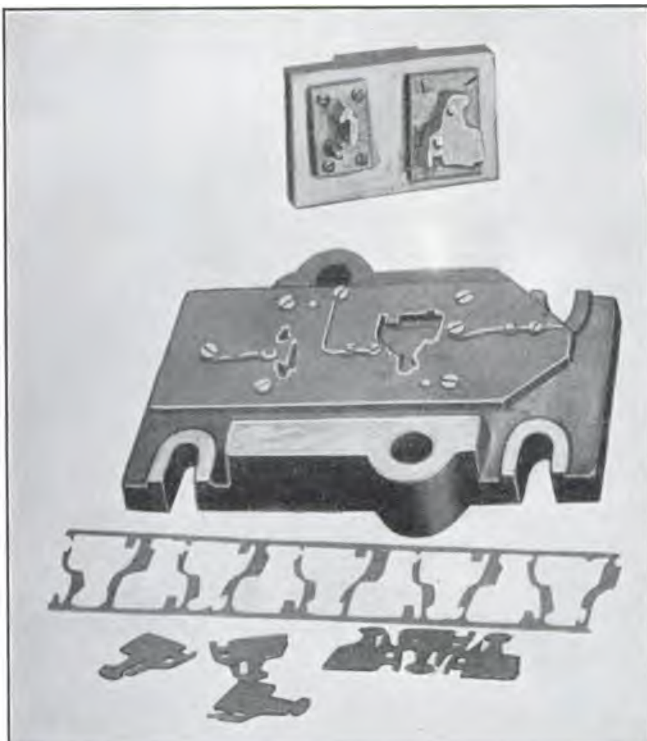


Fig. 376. — Piercing and blanking die

With the broad faces of the blank brought closely together instead of leaving them far enough apart to allow the narrow top to fit in between on the second run, much stock would be wasted.

Fig. 376 in conjunction with Fig. 377 shows the construction of the tools clearly. The strip of metal feeding first under the punches, Fig. 377, is notched by the irregular-outline punch *D* and pierced by the square punch *E*. It then advances under the blanking punch *F* where the end of the stock is stopped by the spring stop pin distinctly shown in the drawing. At the next stroke of the press the blanking punch cuts out the blank, the pins in the punch locating the stock accurately so that the blanking is done in correct position relatively to the openings cut by the piercing punch. Following this, each down stroke of the press slide finishes a blank.

After the strip has been passed through the dies once it is reversed as stated, and then fed through against another set of stops so that the blank stock left between the openings punched in the original passage through the dies, is pierced and a second row of blanks cut out. This is indicated

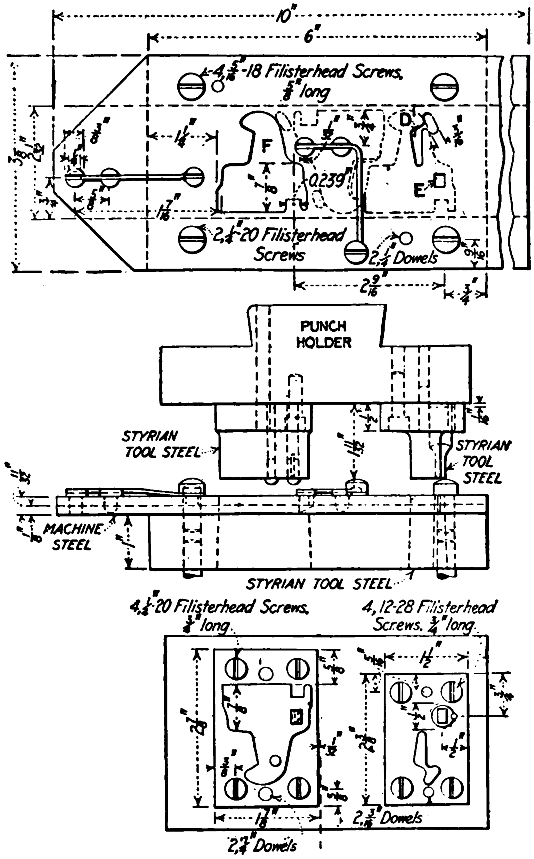


Fig. 377. — Piercing and blanking die

by the dotted lines in the plan view, Fig. 377, which shows the manner in which the stock is stopped against the spring plug in its second run through the press.

The Bending Tools

The bending or forming tools are seen in position in Fig. 378. They consist of a simple punch and a die with a gap of the right width to bend up the ears on the opposite sides of the blank, and a suitable nesting pin over which the blank is located properly before the punch descends. The die carries a shedder which is forced down against the spring action to allow the blank to be bent up on opposite sides. Upon the up stroke of the

press, this shedder forces the formed work upward and out of the tools. The margin stops are then ready for the piercing operation performed by the tools illustrated in Figs. 379 and 380.

The press tools for the final piercing are illustrated by Fig. 380, and the construction will be understood upon examination of Fig. 379. It should

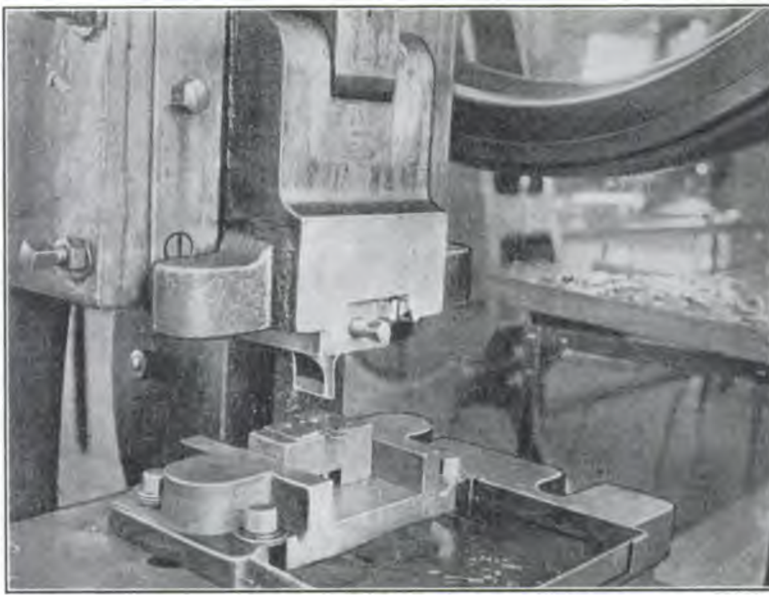


FIG. 378. — The bending tools

be noticed that the purpose of these tools is to pierce the plain side of the blank exactly in line with the hole and notch punched in the opposite side in the first operation as already described.

The method of alining these holes in the press tools is shown distinctly by Fig. 380. The dies are made right and left hand, and perform exactly the same work, but on opposite sides. The work is nested on the punch. That is, the bent blank with the holes punched in one side, is slipped up over the punch and when the punch and work descend together, a leaf on the die, which is shown in Fig. 379, snaps shut and, coming between the upper and lower wings on the formed blank, is designed to serve as a stripper on the upstroke of the punch. The tools shown at the right of Fig. 380 represent the punch in its lower position and show the method of operating this pivoted stripper. The letters on the drawing will enable this operation to be understood.

As the punch comes down, it strikes the leaf on the stripper, which is swung into place between the two wings of the bent blank. In this po-

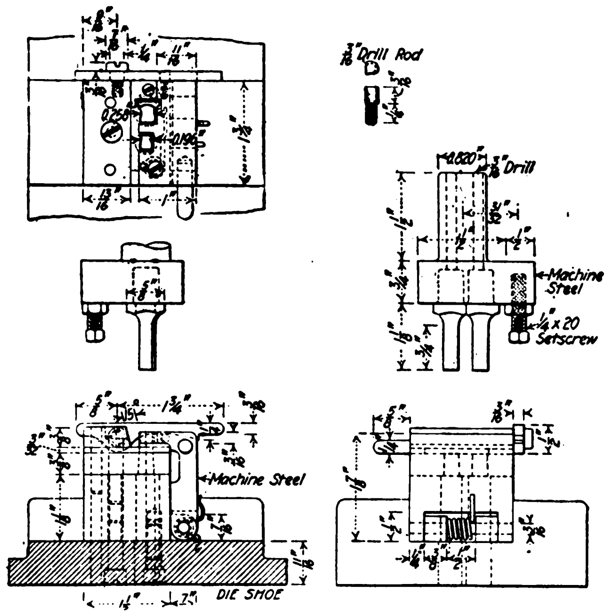


Fig. 379. — Details of piercing tools

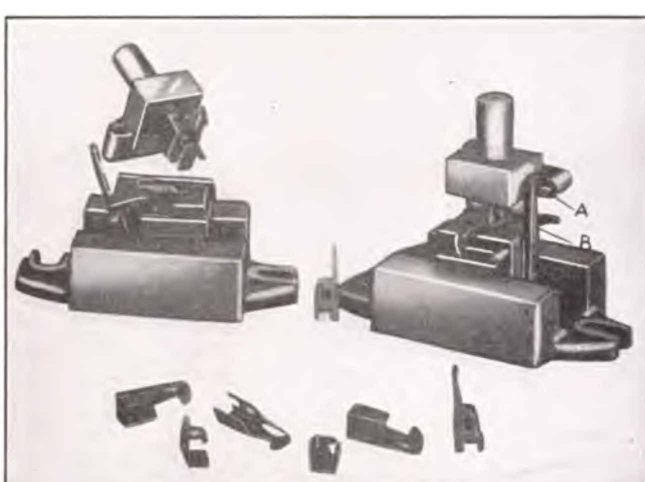


Fig. 380. — The press tools

sition the leaf is locked shut by a beveled-end spring plunger lying horizontally, which snaps outside of the vertical lever on the side and slides along up this upright when the punch ascends.

This arrangement of locking mechanism and releasing device for the stripper is illustrated in Fig. 380, where the horizontal spring plunger can be seen at A, while the lever against which it acts and rests during its upper

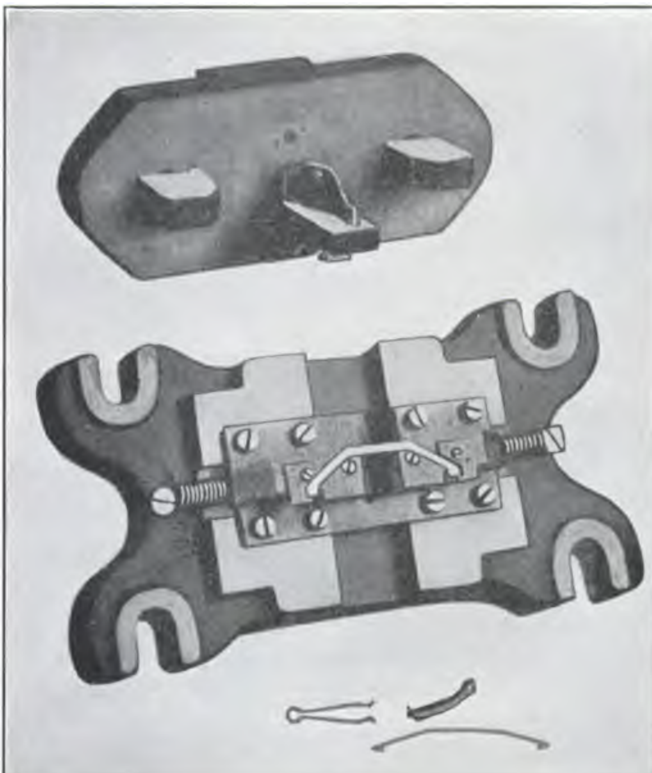


Fig. 381. — Bending tools for a spring

stroke is at B, which is slightly modified from the construction details shown in Fig. 379, although in principle remaining the same. When the punch has reached the top of its stroke, the spring plunger is out of contact with the lever. The latter then swings outward, allowing the stripper to fly open so as completely to clear the work, which is then removed from the die and another part put in place for piercing. This arrangement forms a safety device for the die and punch; for if the stripper were to swing open during contact of the punch, the latter or some part of the die might be broken.

Bending Tools for Typewriter Springs

The tools in Fig. 381 are for bending a ribbon reverse detent spring for the same typewriter. This spring is shown in the detail, Fig. 382. Fig. 383 gives a plan and side view of the press tools for the work.

The material is tool steel 0.020 in. thick, and the strip stock is $3\frac{1}{8}$ in. wide. Before bending the spring the blank is punched practically the full width of the stock, the blanks being formed crosswise of the strip. The character of the blank as it appears before bending is well illustrated in Fig. 381, where a blank and two springs are seen in the foreground, and on the face of the die a blank ready for bending. It will be seen from this illustration that the work is nested between angular guide plates on opposite sides of the die proper. The die itself consists of two movable jaws, which are carried in a longitudinal guide in the die block and slide toward the center when acted upon by the descent of the punch. These jaws are clearly shown in Fig. 383. It will be seen upon inspection of this illustration that the rear ends of the jaws are finished at an angle of 45 degrees as indicated at *AA*. Similar sloping surfaces are provided upon the inner faces of the blocks *BB*. The blocks are attached to the punch carrier above. When the punch comes down, the members *BB* come in contact with dies *AA* and force them inward, causing the blank to hug the punch closely. As a result, when the latter forces the blank down through, the work is pressed tightly against the sloping sides of the parts in contact with it and the V-shaped spring with the flaring opening at the top is formed at one stroke. It should be noted that the open end of the spring is finished to 90 degrees included angle, this being secured by the angular lower face of the punch indicated at *C*.

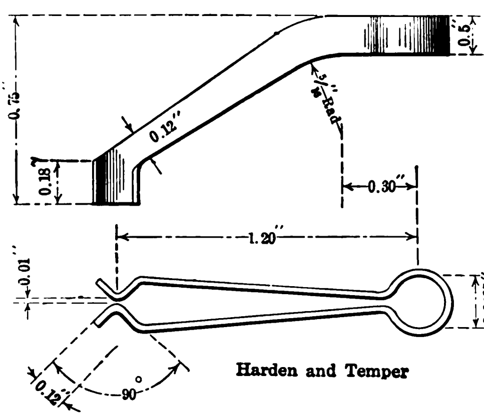


Fig. 382. — Detail of small spring

The partial section in the elevation in Fig. 383 shows a heavy compression spring at *D*. This causes the punch, after it has reached the bottom of the die, to dwell in that position during the remainder of the downward stroke, while the operating blocks *BB* are carrying the jaws *AA* toward the center to form the spring against the faces of the punch.

On the upstroke of the press the die jaws are drawn open by the springs

shown at each side. The formed flat spring is pulled up out of the die with the punch. From this member it is removed by drawing it off toward the front with the hand.

Forming the Ribbon Core

The ribbon core for the typewriter is about $2\frac{3}{4}$ in. long by $\frac{1}{2}$ in. in width. The material is 0.020 in. thick and of the same width as the finished core. The part before and after bending is shown in Fig. 384. When complete

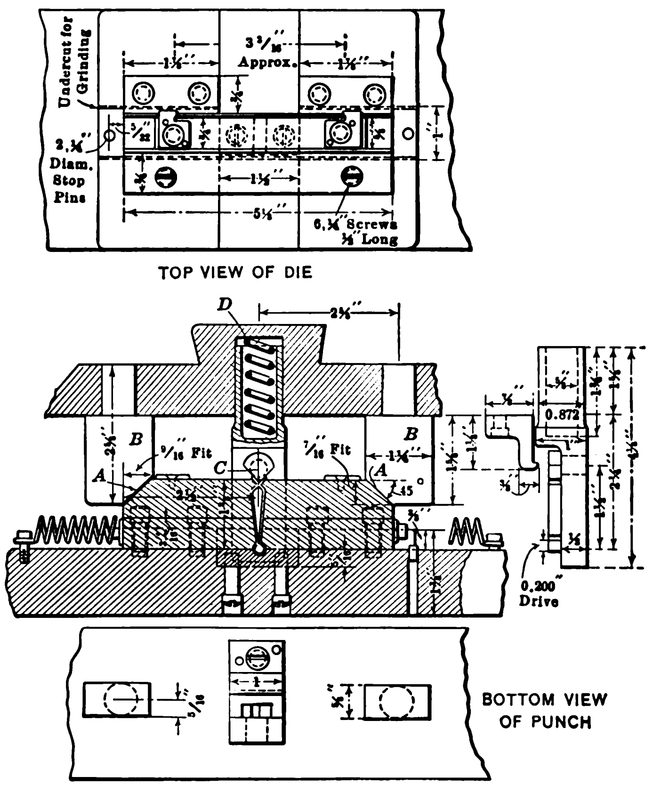


Fig. 383. — Spring forming tools

it is formed into a circular ring 0.76 in. in diameter. At one side is a rectangular recess the full width of the ring. Just below the recess there is an arrow shaped projection, produced by punching a V-slot through the metal, leaving a tongue. When this is bent out from the periphery of the ring it forms a hook upon which the end of the ribbon is secured for winding upon the spools.

The press tools for piercing, forming and cutting off this core are shown in Fig. 385. With the tools in this position the stock feeds in from the left-hand side, although when set up in the press this open side for the

stock guide would come to the right. The strip of material is first fed forward until a shearing punch at the middle cuts off the end squarely, after which the stock is advanced to the stop at the extreme right. Thereafter a core is bent and cut off at each stroke of the press.

The parts as they come from the dies appear as illustrated in the foreground of Fig. 385. The notching punch, which cuts the opening to produce the tongue, is the first in a series of punches and will be seen at the left side in the punch block. The next operating punch is the one in the center, which acts as a shear to sever the work. The rounded punch at the right, with the rectangular groove across its face, forms the work with a semicircular bottom and forms up the rectangular depression across its face. The material is guided under the stripper plate and between pairs of small pins, which control its lateral position accurately. This arrangement of tools means that after the process is once under way a core is being formed up at the right and cut at the same stroke, while the V-piercing punch at the left is cutting out the outline for a tongue for the next core. On the next stroke of the press, the work is advanced again to the stop, this second piece is formed up and cut off while the third tongue is cut out in the stock. When the blanks leave the press, they are in a U form. They are bent to a complete circle by another set of tools not shown here. The ends of the work overlap in the finished ring about $\frac{1}{8}$ in. and are joined under an electric welder while held on special fixtures.

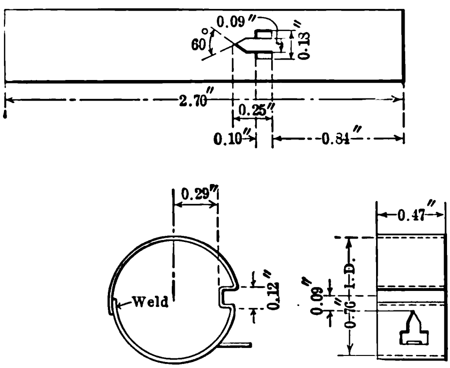


FIG. 384. — Detail of ribbon core

DIES FOR CALCULATING MACHINE PARTS

The views, Figs. 386 to 402, illustrate some of the press tools for manufacturing parts for the Marchant calculating machine, various other dies for which are shown at different places in this treatise.

The group of parts in Fig. 386 represent the stages in the development of a cover for the carriage of this machine, from the plain steel blank, to the formed, trimmed, and finished article. In this view the sequence is as follows: *A* shows the blank; *B* the blank with the long end pierced; *C* the blank with both ends pierced; *D* the stamping of the numerals on the long end; *E* the stamping complete; *F* the forming of the cover to shape; *G* the embossing of the bend along the long row of square openings; *H* the cover trimmed to width and thus completed.

Details of the blank are given in the line drawing, Fig. 387, and the

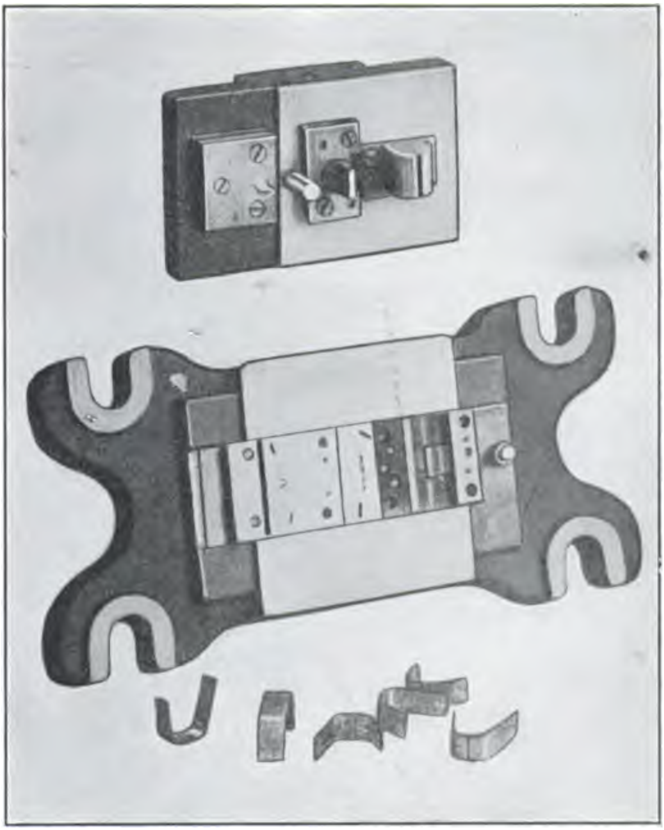


FIG. 385. — Bending tools for ribbon cores

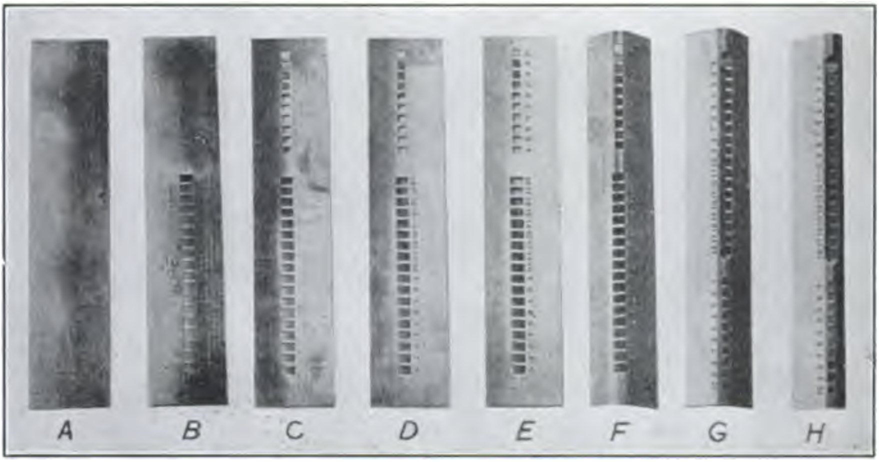


FIG. 386. — Operation in making a calculating machine cover plate

piece complete is shown by Fig. 388. Fig. 387 shows the cover to be 9.215 in. long over all, and the blank width to be $1\frac{13}{16}$ in. The stock is 0.040 by 2 in. cold rolled steel. There are 18 rectangular holes pierced from one end and 10 square holes from the other. After the area enclosing the row of 18 openings has been embossed (following the forming operations) the holes appear as in the drawing, Fig. 388.

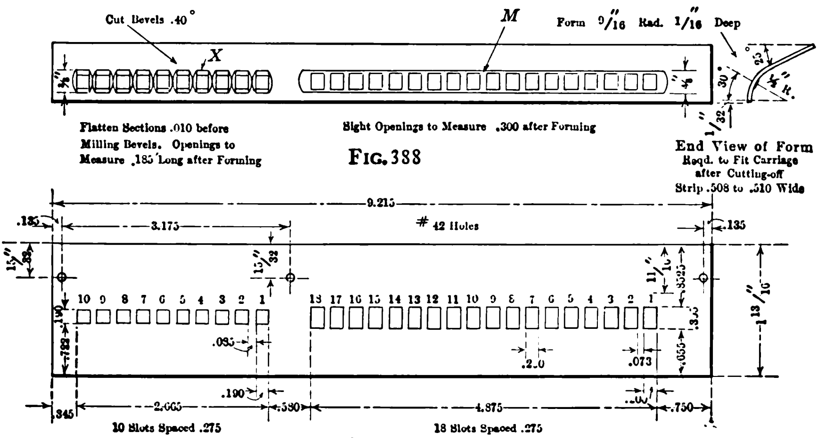


FIG. 387

FIGS. 387–388. — Detail of cover plate

THE BLANKING TOOLS

The first and second operation dies, for blanking and piercing respectively, are shown in operation in the press, in Figs. 389 and 390. The blanking tools are seen in detail in Figs. 391 and 392, the latter engraving including the general dimensions of the punch and die.

The die, it will be noticed, is of sectional construction, in which four separate die blocks are put together, two for each side 9.215 in. long, and two for each end $4\frac{7}{16}$ in. long. The die sections are all $1\frac{5}{16}$ in. wide and 1 in. deep. They are of tool steel, hardened, and ground accurately to dimensions. The long sections are secured by four $\frac{3}{8}$-in. fillister head screws and three dowels of the same diameter; the short end sections are similarly held to the base by two screws of the same size and two dowel pins.

The inner edges of the die sections are all ground to the usual clearance of $\frac{1}{2}$-degree taper. The method of construction enables the die blocks to be hardened and then ground to size to assure accuracy in all respects. Also, it permits the sections to be corrected for wear by grinding the contact faces and setting up if at any time this becomes necessary.

The punch is made up of a single block of tool steel hardened and ground to dimensions with all edges square and parallel. It is fastened to its holder by means of four $\frac{3}{8}$-in. fillister head screws and two dowel pins.

The stripper is a machine steel plate which is seen clearly in the photograph, Fig. 391, and in the front elevation, Fig. 392. It is made with an opening $\frac{1}{8}$ in. longer and wider than the die opening to give a clearance space $\frac{1}{16}$ in. wide all around the punch when the latter descends. The

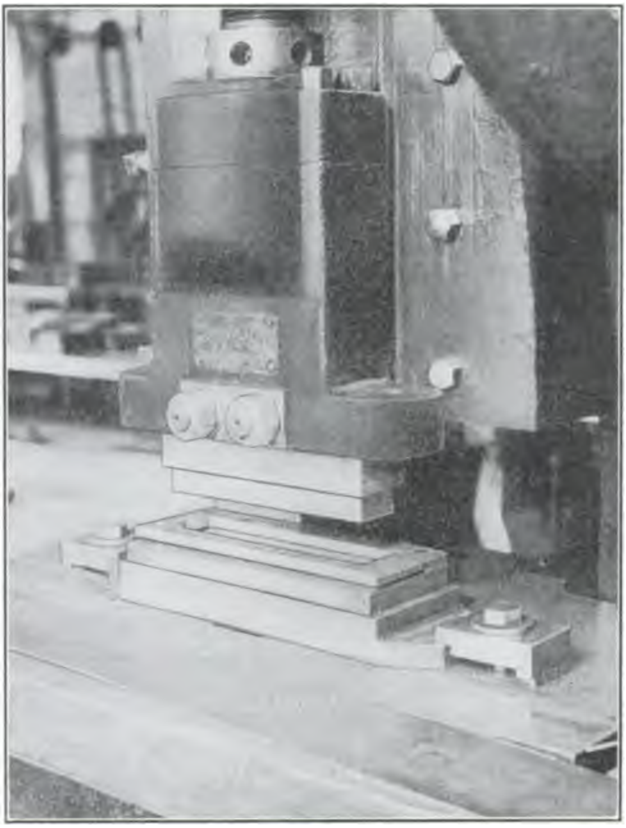


FIG. 389. — Blanking dies in operation

stripper is $\frac{3}{8}$ in. thick and is mounted on guide strips $\frac{5}{32}$ in. thick to allow the stock to pass through readily. The left end of the opening in the stripper is milled out to provide a $\frac{1}{2}$-in. opening over the stock which will be noticed in the photograph, Fig. 391. This stop is low enough to allow the strip of material to be lifted and passed along to successive positions without difficulty during the operation of the press. The appearance of the scrap strip after leaving the dies is shown by the photograph of the set-up in Fig. 389.

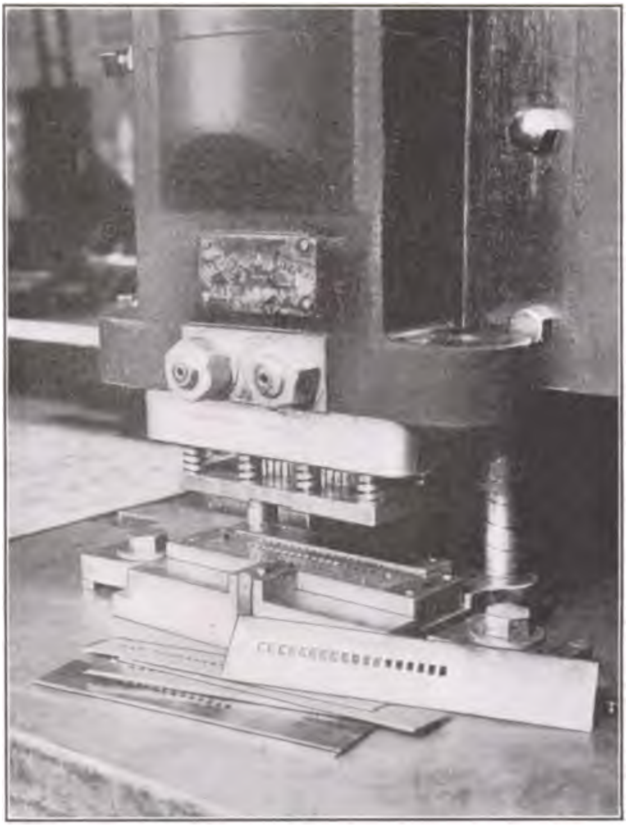


Fig. 390. — Piercing dies in the press

Fig. 391. — The blanking die

PIERCING THE EIGHTEEN HOLES

The piercing operation in Fig. 390 is the punching of the 18 rectangular holes in the long end of the blank. This work is also accomplished with dies of sectional type. The tools are shown in Fig. 393 with a sample of the work in front, and in Fig. 394 all details of construction are covered.

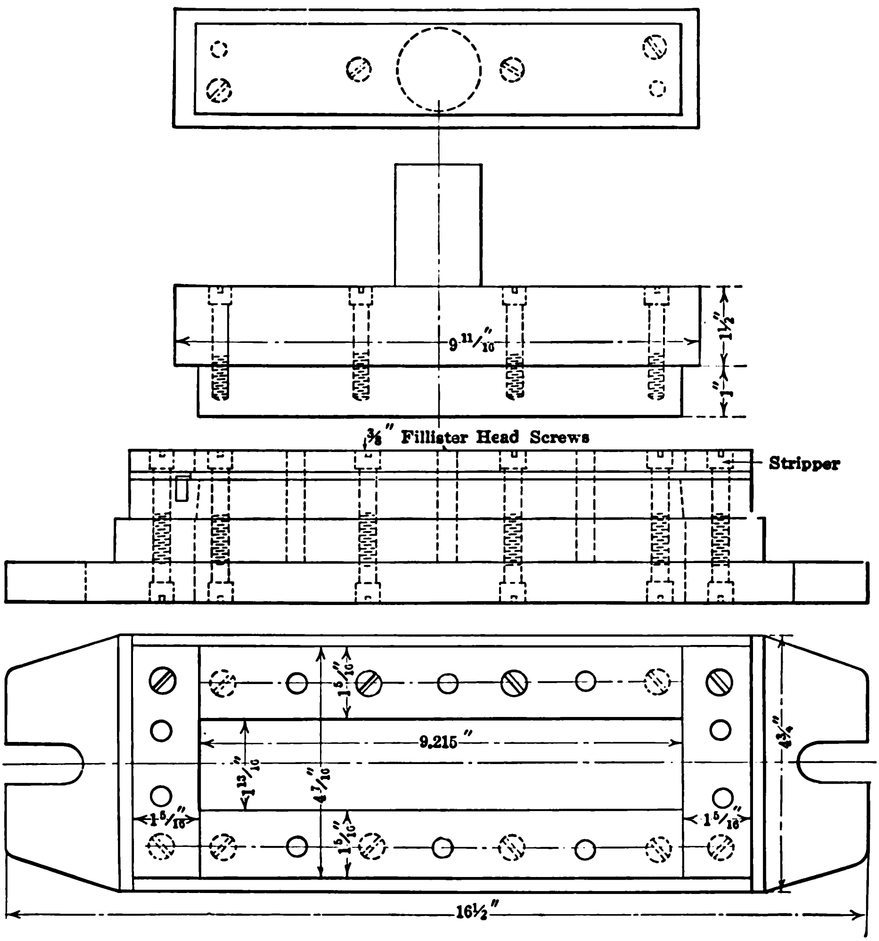


FIG. 392. — Construction of sectional blanking die

The holes pierced are known as "sight openings" as they enable the dial readings to be observed through the carriage cover when the calculating machine is in operation.

The blank rests for the piercing operation against a long back stop on the die and an end stop for the left end of the blank. The blank is pressed back against the rear stop surface by a spring actuated plunger shown at

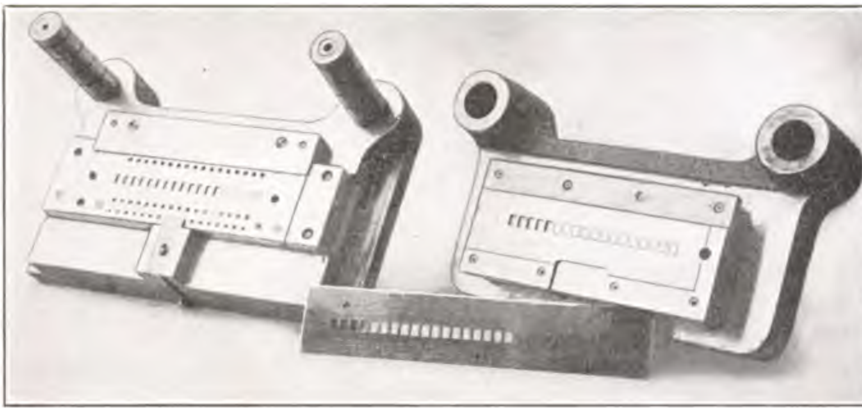


FIG. 393. — Piercing tools for long end

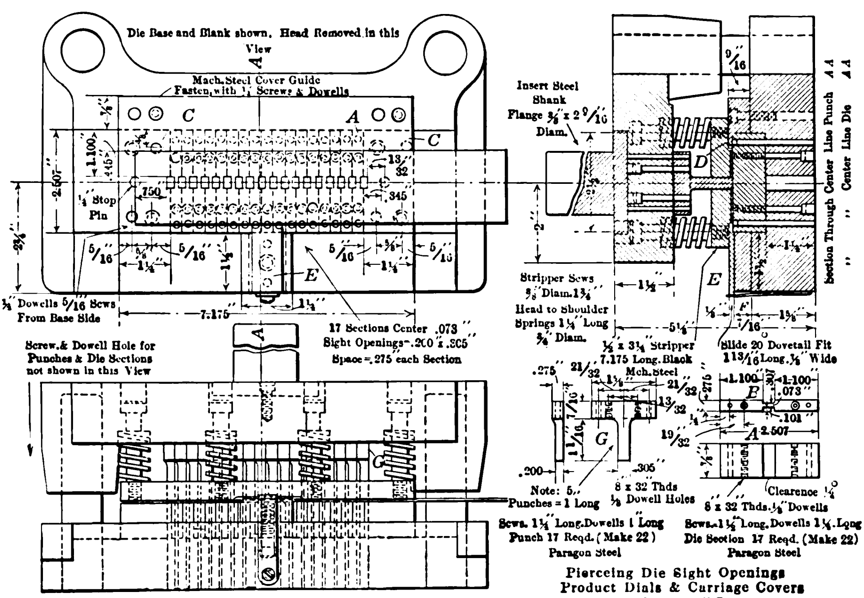


FIG. 394. — Slot piercing die. Sectional construction

the front of the die. The punch head carries a pressure pad and stripper through which the individual punches are closely fitted. This stripper is actuated by stiff pressure springs, four in front and four in back, which are coiled from $\frac{1}{8}$-in. square steel. The stripper is connected with the punch holder or head by eight $\frac{5}{16}$-in. fillister head screws adapted to slide up through the counterbored seats in the holder when the latter descends upon the work.

The Die Sections

The die base and punch holder are cast to the form shown in the drawing. The die base is planed out lengthwise to provide a channel in its face 2.507 in. wide by $\frac{3}{8}$ in. deep for the reception of the die sections *A*, of which there are 17 in all. The die sections are made 0.275 in. wide by $\frac{7}{8}$ in. deep and are 2.507 in. long to fit the seat planed in the base. The die section is made with half the width of opening in each side as at *B*, and the long dimension of the opening is 0.307, or two thousandths more than the width of the punch for clearance. The punch is, of course, 0.305 in. the same as the slot required in the blank.

With the die section made symmetrical as shown, there is less likelihood of its springing when hardened and it is in some respects easier to construct in the first place as the depth of cut on each side for grinding is only half what it would be if the opening were all from one side.

There are two 8 × 32 thread screw holes in each section and two $\frac{1}{8}$-in. holes for dowel pins. The sections are all ground on the sides to bring them to the uniform width of 0.275 in., and the cutting portion at *B* is ground $\frac{1}{2}$ degree taper for clearance for the passage of the slugs punched out in operation.

At each end of the series of 17 die sections *A*, there is a wider block *C* (measuring $1\frac{1}{4}$ in.) to secure all in place. At the back there is a guide plate of machine steel which overlaps the ends of the die sections as at *D*. In front is located the dovetailed slide *E* which is forced forward by the flat spring *F* to keep the work in contact with the guide at the rear.

The Punches

The individual punches are made in the form represented at *G*. They are of tool steel, hardened and provided with a T-shaped head ground to a thickness of 0.275 in. and in this case the punch proper is flush with one face of the head so that by placing the punch flat on the magnetic chuck the opposite face may be readily ground to thickness. The same size of screws and dowels is used here as for the die sections. The appearance of the series of punches when assembled on the head is shown by the front elevation in this drawing.

The punch head and die base are provided with 1-in. guide pins for aligning the tools, thus giving them the sub-press type of action.

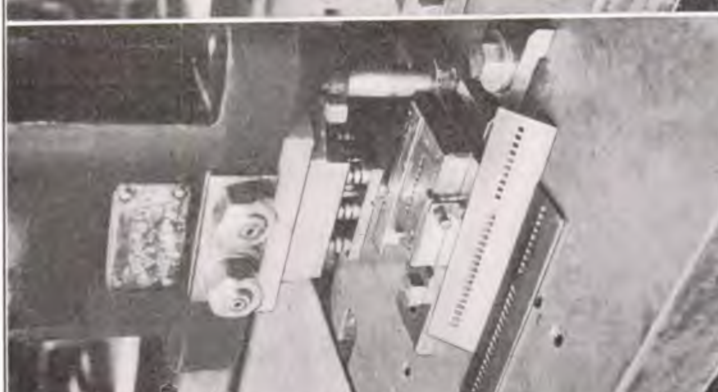


FIG. 395. — Piercing

FIG. 396. — Forming

FIG. 397. — Trimming

The second piercing operation, Fig. 395, punches the shorter row of holes in the opposite end of the blank. The tools are shown removed from the press in Fig. 398. The work is located on the die base by a square stop

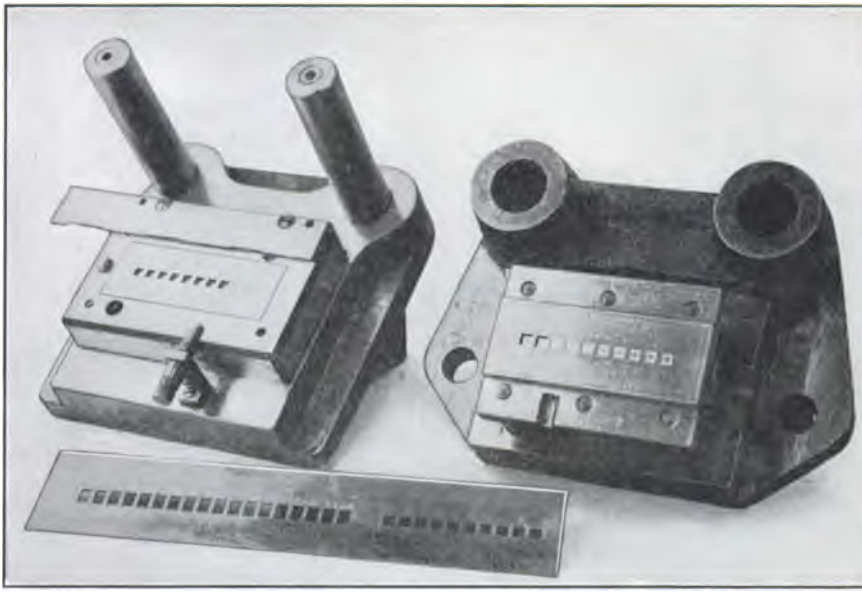


FIG. 398. — Piercing tools for short end

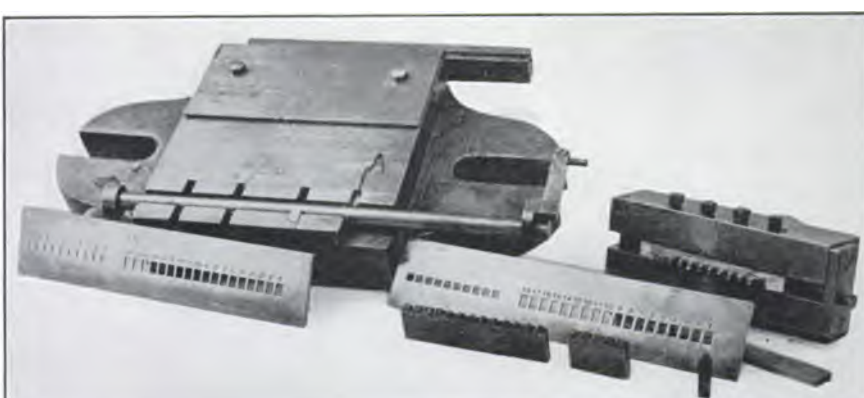


FIG. 399. — Stamping tools for marking numerals

pin which enters the last hole in the long row already pierced and so the position is accurately fixed in relation to this first series of openings. The back of the work rests against the guide strip at the rear of the die, and it is pressed lightly but securely against the guide by a spring plunger which bears against the front edge of the blank.

Stamping, Forming, and Embossing

The stamping of the face of the blank with the numerals opposite the two sets of openings is accomplished with the dies in Fig. 399. The two series of stamps are used separately in a holder like that shown to the right in the engraving. The die is a flat steel plate on a cast base, with an ad-

Fig. 400. — The forming dies

Fig. 401. — The embossing die

justable stop rod at the front which is set by turning it in its seat to swing the pin A out of the notch in the die plate and allow it to enter the desired stop opening. This rod has a gage arm at the right-hand end which carries a screw point for adjustment to close settings endwise. The work rests against the guide plate at the back of the die with its end located against the stop screw referred to.

The steel stamps for forming the numerals in the work are adapted to be slipped into the punch holder and there secured by the series of screws at the front, and the small end binding screw at the right.

The forming dies, Figs. 396 and 400, bend the blank up lengthwise to an angle of 115 degrees included. These dies are simple forming tools which require no description. The work passes from this operation to the embossing dies, Fig. 401, where the surface *M* (Fig. 387) is depressed as at *N* to form a concave portion extended to include all of the cross bars of metal left between the square holes by the piercing tools. This effect is clearly shown in Fig. 401. A section through the dies is reproduced in Fig. 402. This shows that the embossing punch *A* is provided with a heavy pressure pad controlled by ten ½-in. springs for holding the work in the die seat *B* while the formed edge is concaved to the form at *C*. The opposite end of these dies is made to flatten the surface along the short series of holes at the other end of the work. Afterward, the bevel edges at *X* (Fig. 388) are produced by a milling process.

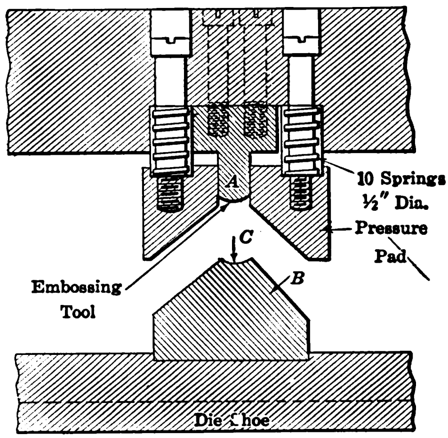


FIG. 402. — Section of embossing dies

FIG. 403. — The trimming tools

The final operation in the press tools is shown by Fig. 397, this being the trimming of the edge to a definite distance from the sighting holes. The tools for this are also shown in Fig. 403. The method of holding the work on the fixture (for the die is in the form of a tool of this character) is shown by Fig. 397 where the formed cover plate is seen resting upon a

locating ledge on the face of the device while two knurled head screws are used for clamping the work in place. In this position the projecting edge of the piece will be trimmed to the exact width required. The cover before and after trimming is shown in Fig. 403.

The punch or upper trimming tool is sheared lengthwise about $\frac{1}{16}$ in. in the length of 10 in. and also has a side clearance of about 5 degrees, both being to assure free cutting action and smooth edged results.

Drawing and Forming a Four-sided Cover

The illustrations that follow relate to the manufacture of another form of mechanism cover for the same make of calculating machine. The production of this article involves the application of the processes of blanking, drawing, trimming, piercing, and forming in press tools, and the taking of one cut in a milling machine. The sequence of operations is represented by the group photograph, Fig. 404, which shows the work from the blank to the finished cover. In this view, *A* shows the blank; *B* the first draw; *C* the second draw; *D* the piece burnished; *E* the bottom and ends milled off with a cutter; *F* the ends trimmed; *G* the finger hole and slots pierced; *H* the completed cover with ends bent to shape.

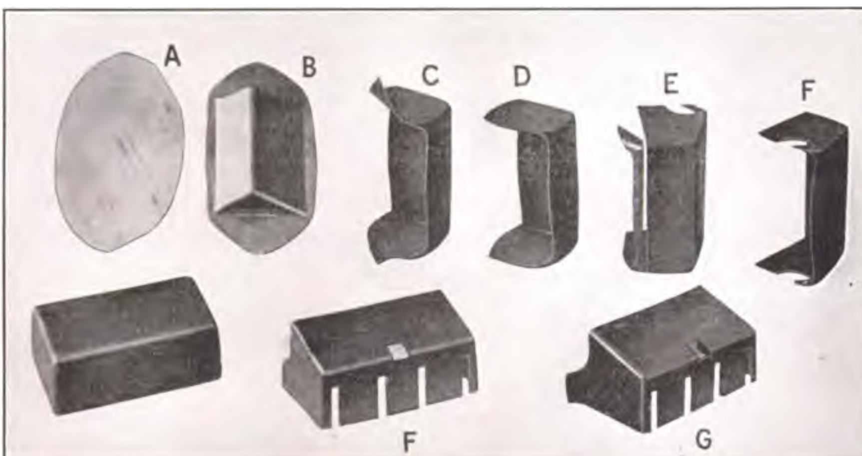


Fig. 404. — Sequence of operation on a small machine cover

Details of the cover are given in the drawing, Fig. 405, and the operation schedule is included in this engraving. The piece is made from 0.040-in. brass stock.

The blank is made with dies of simple sectional construction, the die itself being constructed in halves. This die is shown in Fig. 75 in Chapter II and need not be reproduced here. It makes a blank similar to *A*,

Fig. 404, which is of elliptical form with a length of $5\frac{3}{4}$ in. and a width of 3 in. The operations that follow give a good opportunity to study the evolution of a blank of this contour through the successive shapes it assumes until it is completed.

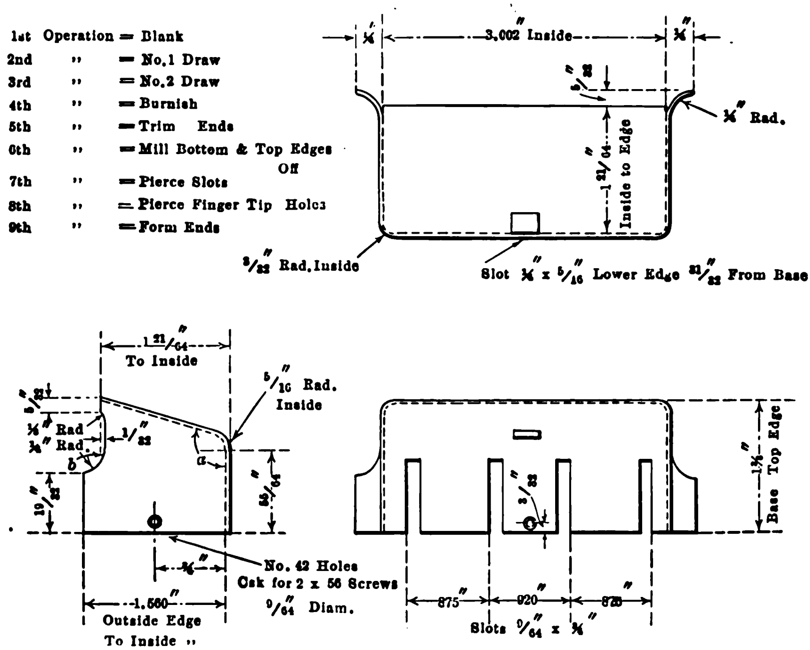


FIG. 405. — Detail of carriage cover for calculating machine

THE DRAWING OPERATIONS

The first drawing operation is accomplished with the dies in Fig. 406. In this case the die proper B is the upper member of the set and the punch B' is carried by the cast-iron base to which it is attached by fillister head screws and dowels, let in from the under side of the shoe. A drawing pad or pressure pad B'' is provided which fits over the drawing post or punch B', and this is acted upon by pressure pins which extend down through the base and rest upon a spring plate C, which receives the upward thrust of the long coiled spring which, when assembled in working position, is secured to the base by the threaded rod shown, this being passed through the center of plate C and screwed into a tapped hole in the base.

This first drawing operation produces a piece drawn in at an angle of about 110 degrees (to correspond with the included angle at the closed side of the cover at a, Fig. 405) and to a depth of about $\frac{7}{8}$ in. The second drawing operation with the tools, Fig. 407, draws the box form to depth as shown by the work at the front of the dies. These tools are in general similar in construction to those for the first draw and they use, in fact,

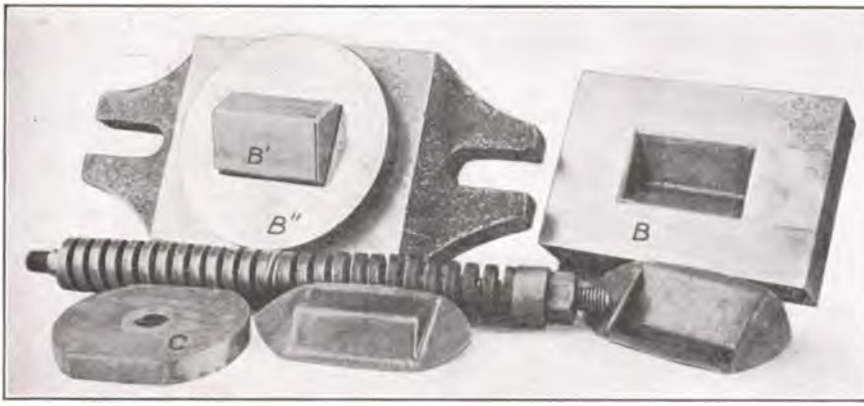


Fig. 406. — First operation drawing die

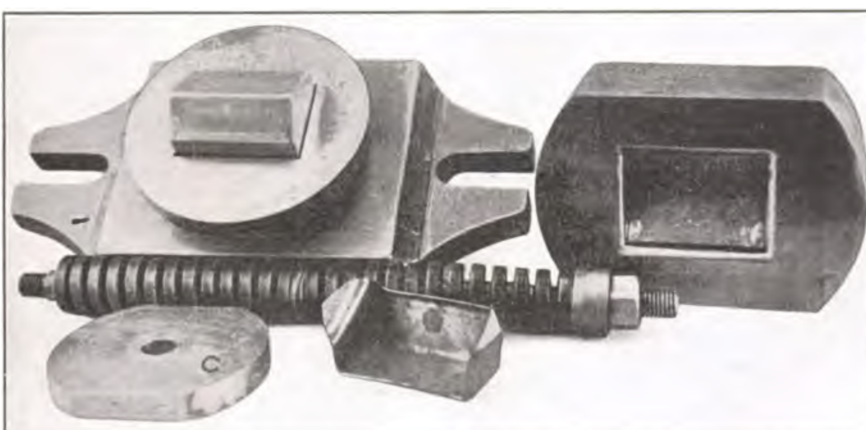


Fig. 407. — Tools for second draw

Fig. 408. — "Push through" dies for third draw

the same pressure plate and spring below the drawing post base. The die, however, is provided with a spring knock out. Both drawing operations leave the work with flared out ends which indicate the manner in which the stock is held between the drawing surfaces to prevent wrinkling of the work.

The next operation is in the dies, Fig. 408, where a "push through" construction is used, these dies straightening out the sides of the work and having a burnishing effect upon the walls.

It should be noted that all of these drawing dies have a liberal radius for the corners to allow the metal to flow into the die without breaking, and the spring tension is regulated to give the desired gripping pressure on the work between the opposing surfaces so that wrinkles are avoided.

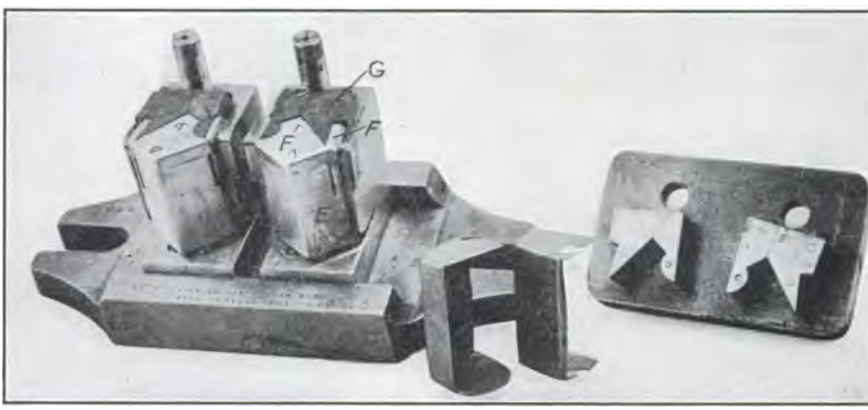


Fig. 409. — Trimming dies

The Trimming of the Ends

The trimming of the ends in the following operation is done with the tools in Fig. 409. These dies are of novel design. They are arranged to receive the drawn cover which is slipped vertically over the die proper and which is then cut out at the edge by the trimming punches to form a concaved opening or notch at that point. The dies are double, right and left hand, and the work is first trimmed at one end over one of the dies, then placed the other end up on the other die for the trimming at the second end.

The shape of the notch cut out by the trimming tools is indicated at *b*, Fig. 405, although the full depth is not here represented as the drawing shows the cover in completed form after a milling operation has been attended to.

The trimming dies, Fig. 409, are made up of machine steel blocks *E* to which are secured hardened tool steel die sections *F* which are seated

against the main block and secured by fillister head screws and dowel pins. The blocks E are cut away at the bottom to admit the lower edges of the work which is slipped over blocks E in upright position, with the bottom ends extending into the clearance slots referred to. The die cutting edges are backed up by a rubber pad, or buffer G which strips the scrap edge after the trimming punch rises. The latter is made in sections for convenience and each section is secured to the punch holder, as plainly indicated, by screws and dowel pins.

A sketch of the general construction of the dies is given in Fig. 410 showing the method of holding the work by slipping it over the main block

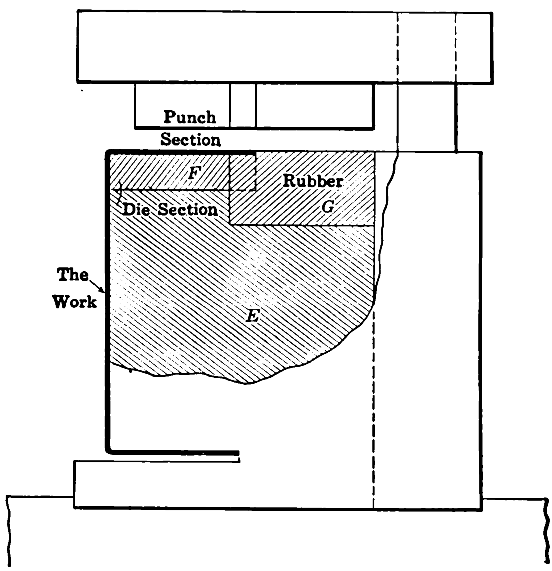


FIG. 410. — Section through trimming die

and resting it on the die sections at the top. The guide posts for alining the punch holder and die base are also indicated here.

Following the trimming in these dies, the surplus metal along the long edge of the cover is trimmed off in a milling fixture with a cut similar to that indicated at E, Fig. 404. Then two piercing operations are performed.

THE PIERCING AND FORMING TOOLS

The tools for the first piercing operation are shown to the right in Fig. 411; these pierce the four slots in the front of the cover. The slots are $\frac{9}{64}$ in. wide by $\frac{3}{4}$ in. deep and they are spaced apart a center distance given on the blueprint, Fig. 405.

The photograph of these slot piercing dies is self-explanatory. The dies are of the sub-pressed order, with stiff guide pins at the rear of die shoe

and punch head. The die blocks are fitted together sectional fashion with the correct gap between sections. The punch is similarly built up with separate sections each made with a square base for securing to the holder with screws and dowels. The punch holder carries a pressure pad and stripper the springs for which are better seen in the second view of the same tools in Fig. 412.

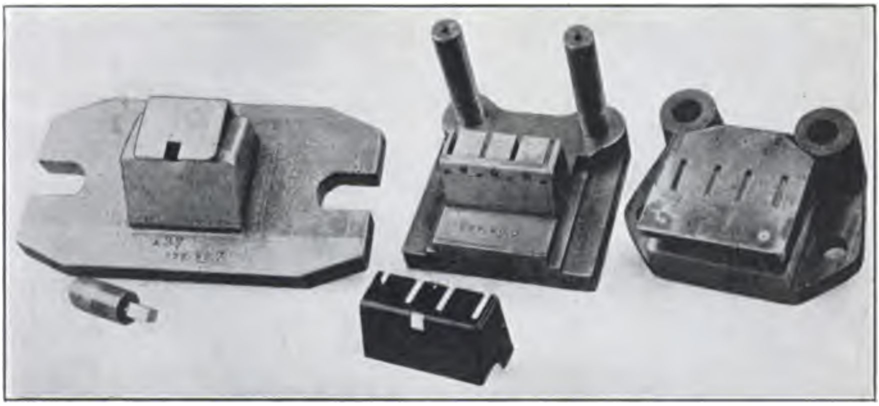


FIG. 411. — Piercing dies for finger hole

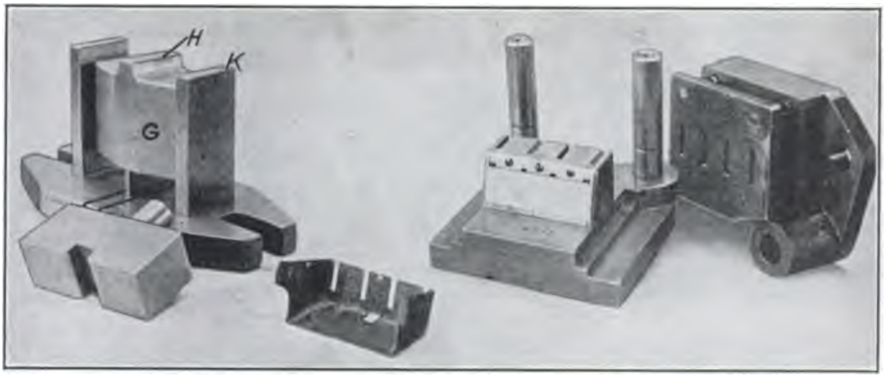


FIG. 412

Forming die Finger hole die

The piercing tools for the small square hole in the top and front corner of the work are shown at the left in Fig. 411. The punch is a simple tool with squared cutting portion milled on the end of a round shank and the stripper is a bent plate secured at the back of the die block and projecting forward to the corner of the die. The work slips under the open end of the stripper.

The forming tools at the left in Fig. 412 bend up the curved ears at the

ends of the cover to a width of $\frac{1}{4}$ in. The die block G for the forming of these ears is shaped for the curve at H which is a projection across the face of the form block. The block G rests upon a narrow support below and its width is enough less than the distance between the uprights K of the base to provide a clearance slot to admit the edges of the cover to be formed. The projecting ears on the cover rest on the top face of ledge H. Two

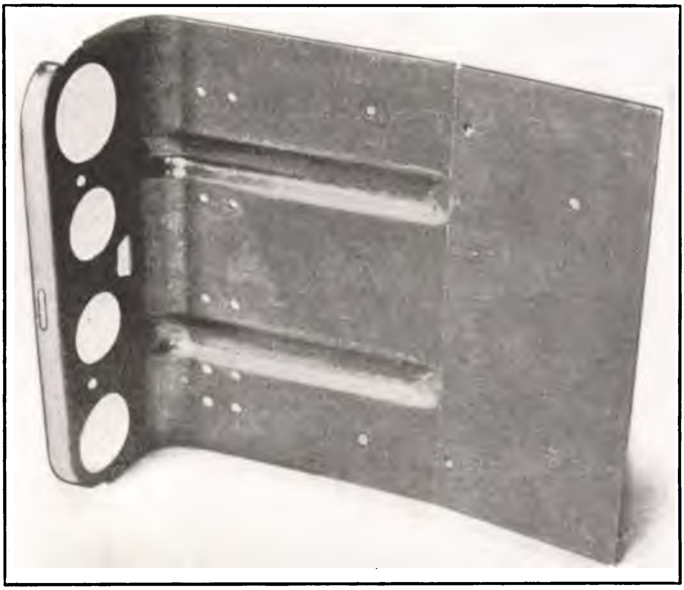


FIG. 413. — Underside of coin changer back

pieces are inserted at once, one from each side of the die block G. The punch then forms the ears down into the curved fillet at the bottom of block H.

COIN REGISTER DIES

The dies in the following illustrations are a few of an extended line of similar tools used for making various parts of the American Coin Register. There are in connection with this work many interesting problems in the bending and forming of different pieces, and one part requiring some well-designed tools for such purpose is illustrated by Figs. 413 and 414. This is a sheet steel member known as a coin changer, which is manufactured by a sequence of press operations.

The stock is 0.062 in. thick. It is cut off under the shear to approximate length and is then trimmed and pierced in the first operation dies, Fig. 415 and 416. The pierced blank then appears as in Fig. 417. The dies are so clearly shown by the half tone and line drawing as to need little

in the way of description. A few features may, however, be referred to briefly.

The sheet metal plate locates against gage pins *A*, *A*, *A*, Fig. 416, and

FIG. 414. — Top side of coin changer back

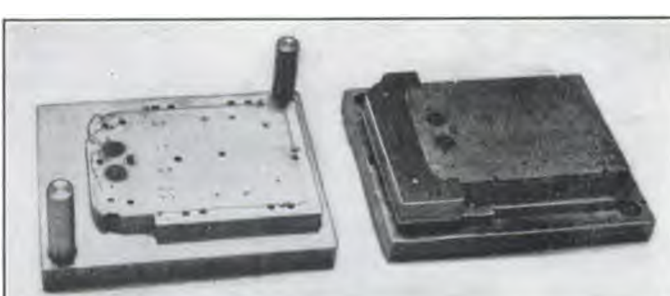


FIG. 415. — End blanking and piercing dies

when the punch plate descends with the end trimming and piercing tools, the pressure pad *P* holds the plate securely and acts as a stripper when the punch ascends. The punch plate carries one bending punch *C′* which forms up the lip at *B*. This punch has three cutting edges to outline the

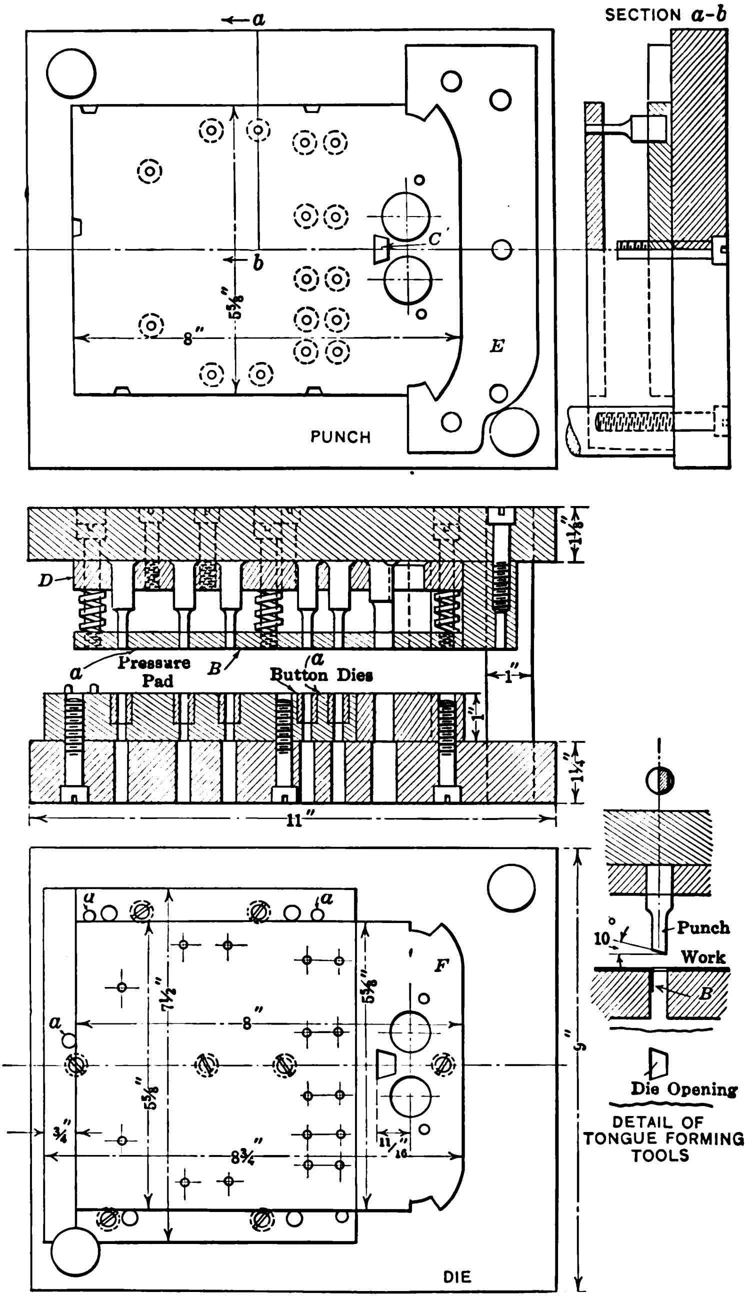


FIG. 416. — End-trimming and piercing tools for first operation

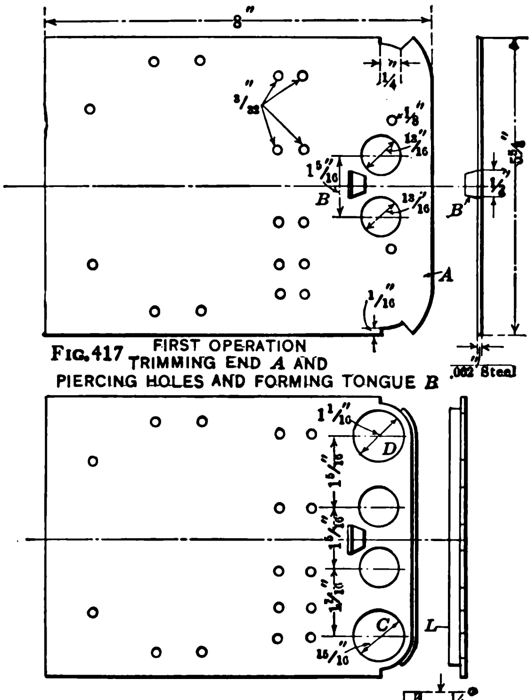


FIG. 417 FIRST OPERATION TRIMMING END *A* AND PIERCING HOLES AND FORMING TONGUE *B*

SECOND OPERATION PIERCING HOLES *C-D* AND FORMING UP LIP *L* AT END

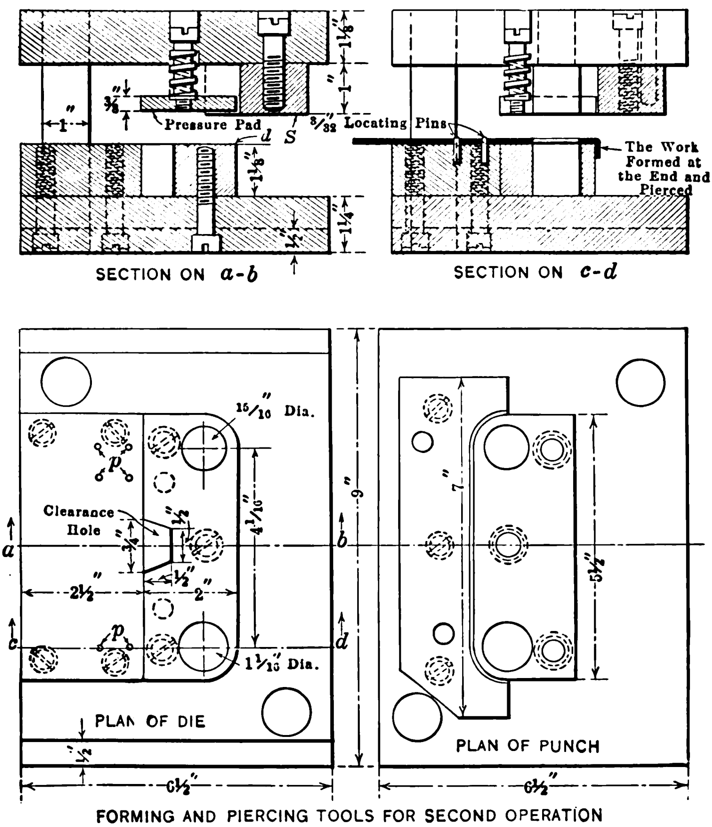
FIG. 418

FIGS. 417 and 418

FIG. 419. — Tools for forming flange at end of work

tongue of metal or lip C, but the back face is narrower than the die opening so that the effect is to cut the outline of C around the three corners and then fold it down into the opening in the die as shown by the sectional sketch at the side of the drawing, Fig. 416.

The large holes pierced in this die are $\frac{13}{16}$ in. diameter. The small holes are $\frac{3}{32}$ in. The piercing punches are set into the plate D and the latter is secured to the punch holder by a number of fillister head screws and dowel



FORMING AND PIERCING TOOLS FOR SECOND OPERATION

FIG. 420

pins. The small piercing dies are of the bushing type and readily replaced if required. The end trimming is done by tools E, carried by the punch head, and F secured to the die shoe. These tools are really on the compound order, the punch section F of tool steel being bored and ground out for the die openings for the large pierced holes. Like the rest of the dies in the series, these are provided with guide pins at the corners of the shoe and holder.

The work as it comes from these dies is shown at Fig. 417. Fig. 418 illustrates it as it appears after the next operation where the front end is formed and bent up to the round cornered lip indicated at *L*.

The End-forming Dies

The dies for forming this shallow flange or lip are shown by Figs. 419 and 420. Referring to the latter view it will be seen that the tools are also used for punching two large holes which are respectively $\frac{15}{16}$ and $1\frac{1}{16}$ in. in diameter. So the operation is again of the combination type. The blank rests over the series of locating pin *p* with its end to be formed projecting over the edge of the die at *d*. The punch section *S* is made to

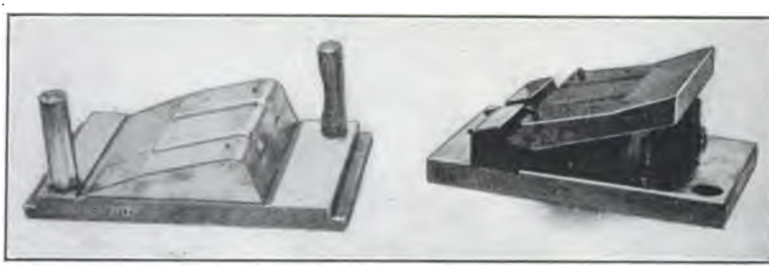


Fig. 421. — Forming tools for changer back

allow just the thickness of the material between its inner edge and the corresponding face *d* of the lower die and when the punch descends it folds the flange down over *d* and forms it to shape.

The clearance hole marked on the die is to admit the narrow tongue formed in the first operation and thus keep it free from the action of the second operation tools.

The pressure pad and its springs are shown clearly, and other features of importance are all detailed in the drawing.

The Final Forming Tools

The tools in Figs. 421 and 422 receive the lower end of the blank which rests upon the sloping face *A* of the lower die with its end against stop shoulder *B*. Upon the upper die descending the pressure pad *C* (which is supported upon four screws and four pins carried in guide bushings) holds the work and the continued descent of the punch forces the work down to the shape of the seat on lower die *A*. The pressure springs are very stiff and they carry the forming die down parallel to the face of the lower die because of the guide formed by the four corner pins *P*. At the same time after the upper die has reached a certain point in its travel, the fixed form *F* bends the other end of the work down over the back of the die at *G* and forms this portion of the piece to shape.

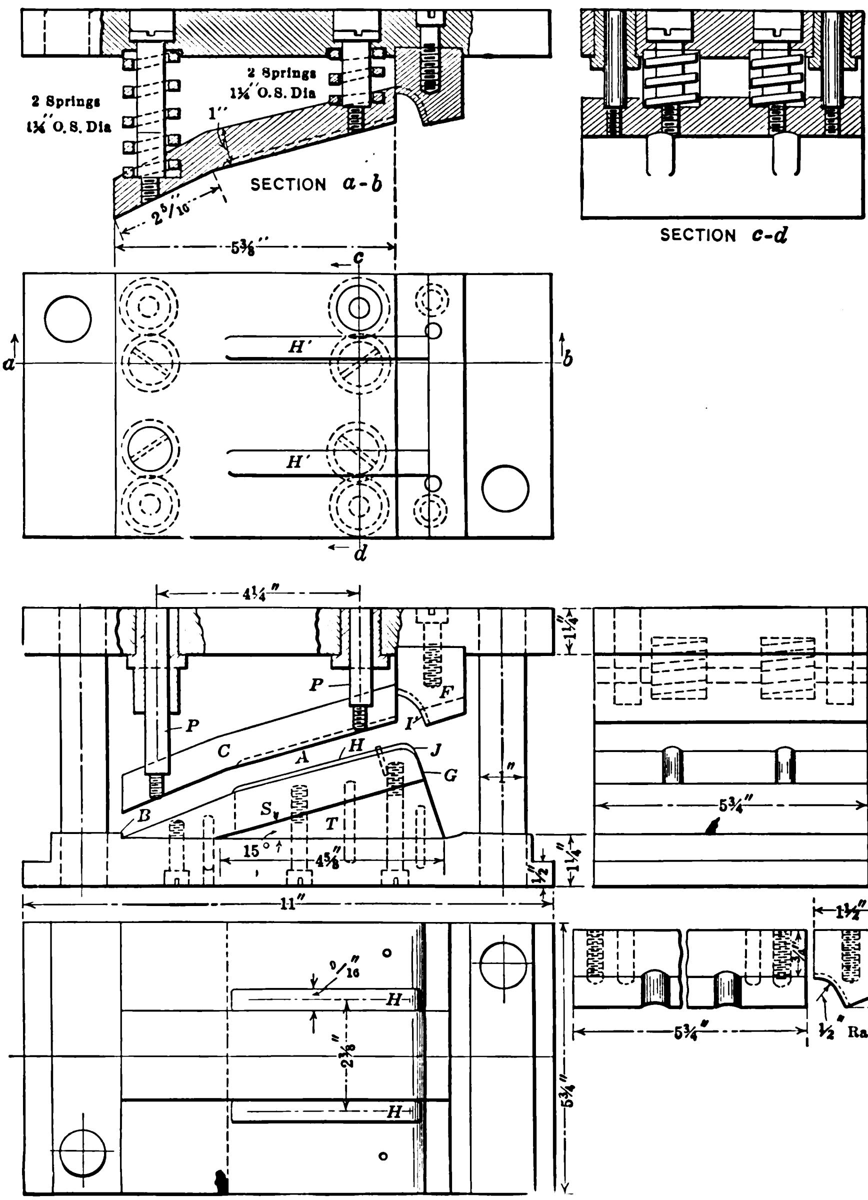


FIG. 422. — Forming dies — third operation

There are two longitudinal corrugations in the work as shown by Fig. 413 and these are produced by the embossing surfaces on the dies at *H* and *H′* respectively. These grooves extend around the curved back as indicated and are continued around the corner by the corresponding surfaces of the die block at *I* and *I′*.

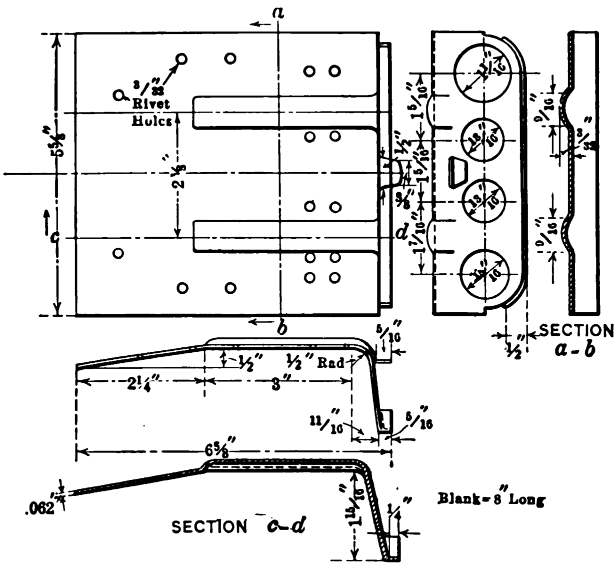


FIG. 423. — Third operation — bending and forming

The lower die is built up of the tool steel wedge shaped section *S* which is mounted upon a taper shoe or block *T* which gives the desired angle of slope or 15 degrees. Both parts are secured to the die base proper by a number of fillister head screws and suitable dowel pins.

THE CASING FOR THE COIN CHANGER

The casing for the coin changer is bent and formed with the tools in Figs. 424 and 425. The casing itself is seen at the right in Fig. 425, at the side of the second operation dies.

This part is made from steel plate blanked and pierced in the compound tools illustrated by Fig. 144, Chapter IV. As it comes from this set of dies it is placed in the first operation forming tools, at the right in Fig. 424 where the ends are bent up to a sharp corner by the punch lip *A* which forces the work down over the end *B* of the lower die. The blank is located in this die by resting with one end against a stop plate at *B* and the blanked narrow body against gage strip *C*. Then in the dies at the left in the same view, the wings are partly formed by starting the bend in angular faced die *B′* and this is completed by the finish dies, Fig. 425,

where the blank is located by two of its pierced holes over locating plugs in the lower die. The distance W between the die jaws is the width to which the work is to be formed and the punch X is made with a face equal to the width of the work measured inside. This punch acts against a spring stripper in the die and when the punch ascends after forming up the work to the outlines shown here, the stripper ejects the finished article from the die.

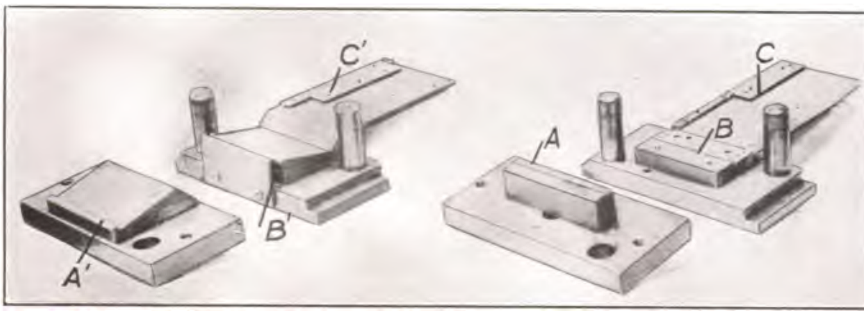


FIG. 424. — Forming tools for coin changer casing

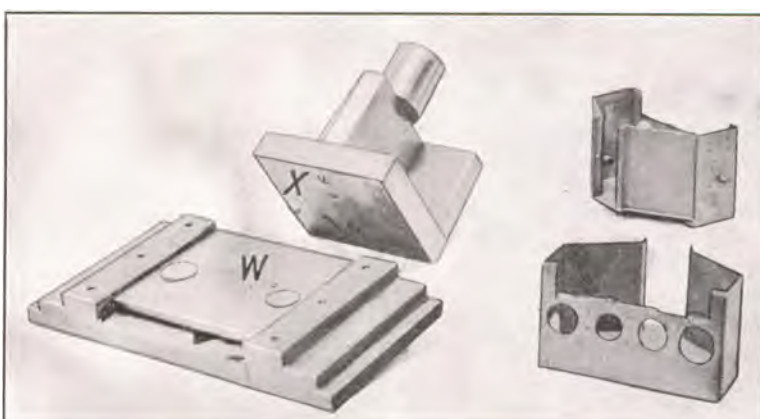


FIG. 425. — Finish forming tools for coin changer casing

SIDE CLOSING DIES

One more die will be illustrated here. This is for the same coin register as the tools just described. It is for forming up a steel cover like that shown in the background of Fig. 426. The work measures in the blank 7.865 in. wide and its ends are bent to lengths of $2\frac{19}{32}$ and $3\frac{27}{32}$ in. respectively. There is a large radius formed in each corner by the bending tools and it is required that the side walls be parallel with one another when the piece

comes from the dies. As there is a certain amount of spring to the material this is compensated for by forming the work with dies that are under cut to allow the work to be bent past the vertical line the necessary amount to give right angle bends when the article has been allowed to spring back after leaving the dies. The small openings pierced in the blank are made at the time the blank is cut out, a combination die being used for this first operation.

The forming dies are shown by Fig. 426. The punch or upper die is made with its sides sloping inward about $\frac{1}{8}$ in. At each end of the punch

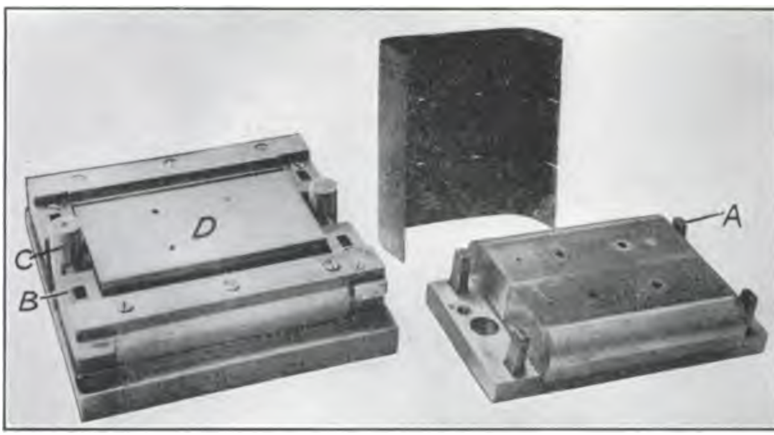


Fig. 426. — A side closing die

holder there are a pair of taper plungers A that are adapted to enter slots in the sliding jaw bars B when the punch holder comes down. The sliding members are normally held outward by compression springs between them and posts C, but when the work is forced down against pressure pad E and the plungers A enter the slots in B the latter members with their jaws move toward the center and fold the work up to the inwardly sloping sides of the punch. When the punch ascends again, the pressure pad rises and the closing die jaws expand under the action of the springs referred to. The slope of the punch sides is determined by trial and for the particular size of work shown it is found that $\frac{1}{8}$ in. is sufficient to allow the formed work to come from the dies with its walls standing vertically.

CHAPTER XII

DIES FOR EMBOSSING, MARKING, RIVETING, SWAGING

Several ratchets of the kind used on the platen of a typewriter are shown in the foreground of Fig. 427. They are about $1\frac{1}{2}$ in. outside diameter by $\frac{3}{8}$ in. thick, with a long hub and a $\frac{1}{4}$-in. hole bored through. The hub fits over the spindle of the rubber platen. The blanks for these ratchets are made in the automatic screw machine. The form in which they come from the machine is seen at *A* and *B*, Fig. 427, where two ratchets

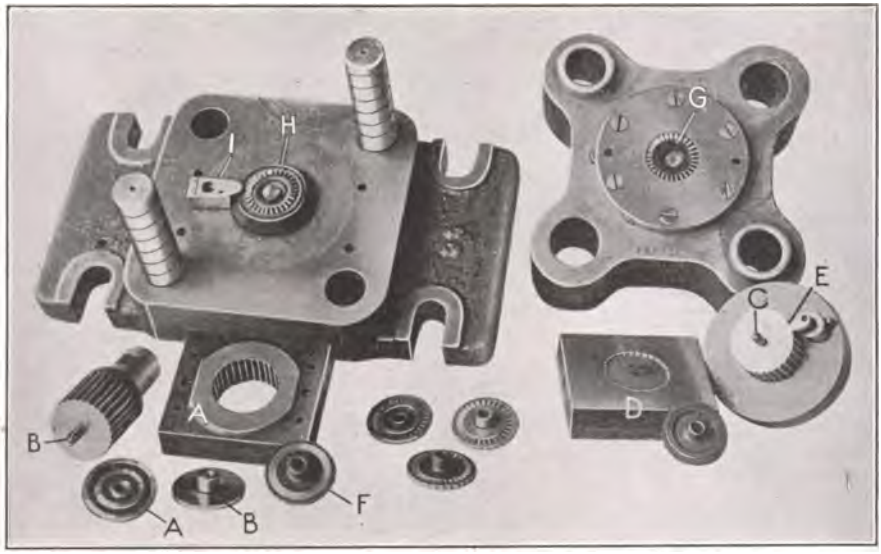


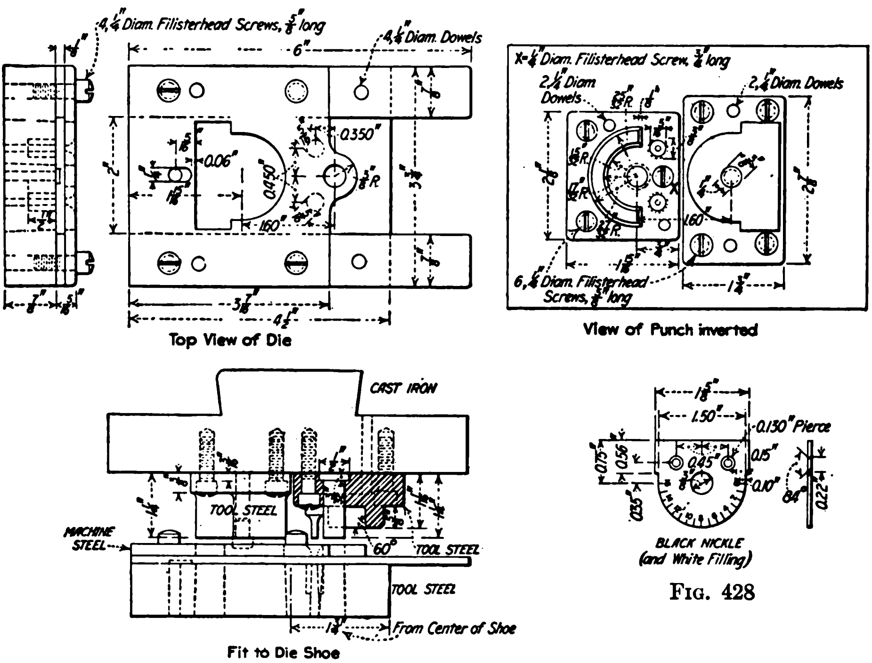
FIG. 427. — Press tools for typewriter platen ratchets

are shown from opposite sides. These blanks are coated with copper. A second machining operation consists in forming the serrations around the edge with the press tools shown at *A* and *B* at the left of the group of tools in Fig. 427. Then the serrations are shaved with the tools at *C* and *D* at the right. These tools consist of a shallow shaving die and of a punch that is adapted to act also as a nest for the blank. The pilot on this punch has a slot cut crosswise of the body with a spring projecting at either side and serving to retain the work in place when it is slipped over the pilot.

There is at one side of the punch a locating stop E, which enters one of the notches in the edge of the blank and thus serves as a locating stop to position the blank in alinement with the grooves in the punch shown at C.

The next operation consists in placing the blank in the hand screw machine, cutting the shallow groove around the outer face, as at F, to allow carbonization of the blank along this channel only. The copper surface protects the remainder of the work in the heating process.

The next operation is performed in the press with the punch and die at G and H. The lower die has at I a round-ended locating stop on which



FIGS. 428, 430. — Tools for indicator

the blank is nested in position on this die and which locates the outer serrations correctly in relation to the die teeth below. This lower die also carries an ejector pin at the center for forcing the blank out of the die ring upon the upstroke of the press. The action of the upper die in its descent over the corner pillars is to force the ratchet-shaped teeth through the side of the groove in the blank at one stroke. The next operation is hardening the smooth surfaces, the outside serrations around the blank, the ratchet teeth outside and inside wherever the bare metal is exposed by machining after copper-plating the piece. That is, wherever the blank is exposed by machining after coppering the piece, it hardens to prevent wear of the tooth edges

A crank is used for adjusting the typewriter carriage in relation to the type, to allow for one or more thicknesses of paper, according to the character of the work being done on the typewriter. In the movement of this crank, it passes over the face of an indicator dial at the front of the machine. This dial is graduated in the manner indicated in Fig. 428, the numbers running from 0 to 16. There is a $\frac{3}{8}$-in. hole in the center of this plate, which passes over the neck of the adjusting screw. This plate is pierced and blanked with the tools shown in Figs. 429 and 430.

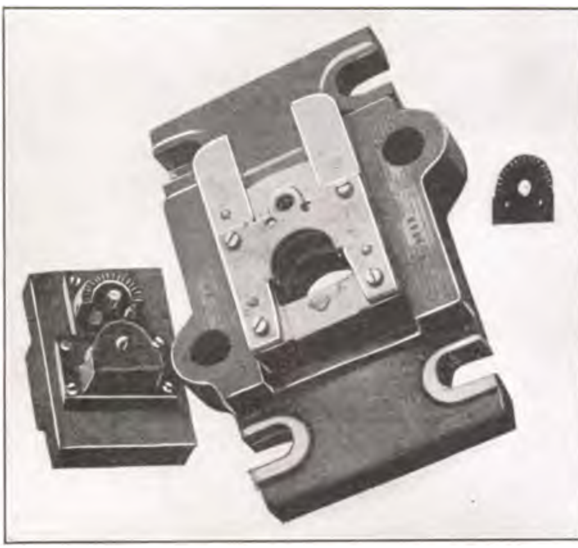


Fig. 429. — Tools for indicator blank

As will be seen upon examination of the illustrations, these press tools are of tandem character; that is, the three holes are pierced in the stock before the blanking is done. At the same stroke that puts the three holes in, the graduations and the numerals are struck into the face of the stock. The next advance of the strip of metal feeds the work against stop pins at the left-hand side of the die. The following downstroke of the press and blanking tools cuts the work out to the outline shown. The lower face of the blanking punch will be seen provided with a conical-pointed pilot pin that enters the $\frac{3}{8}$-in. hole already pierced in the work.

The small piercing punches for the two screw holes are made of $\frac{5}{16}$-in. drill rod turned down to the required size for the screws. The stripper plate is countersunk deeply around the opening for these small punches in order that the neck of the punches may pass well down into the plate and give suitable support to the ends of the small punches themselves. Owing to this liberal opening in the stripper, the punches are made with a sweeping

fillet instead of being brought to anything like a sharp corner. Thus they are much more substantial in operation than is often the case where a liberal fillet of this kind is not permissible.

The plan view at the upper right-hand corner in Fig. 430, showing the base of the embossing and piercing punch as well as the blanking punch, illustrates clearly the method of attaching both punch blocks to their cast-iron carrying block. Three screws are used in the case of the graduating die, along with a pair of dowels, while four screws are applied to the holding of the blanking punch itself.

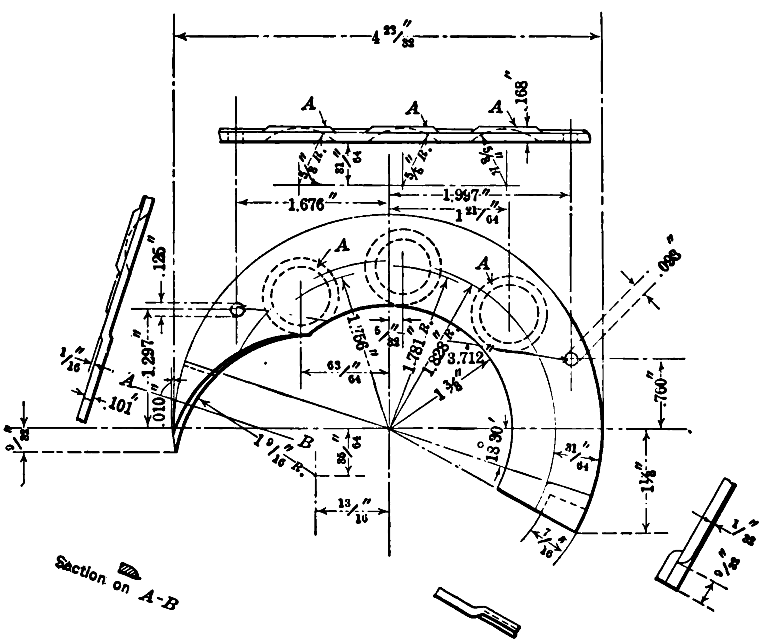


Fig. 431. — An embossed piece

An Embossed Crescent

The arc shaped piece in Fig. 431 is manufactured of 0.101-in. brass with the press tools in Fig. 432. The blanking dies at the left have no special features beyond the pillar arrangement for guiding the punch plate and the trigger form of stop actuated by the adjustable screw in the punch holder. The embossing dies are shown at the center of the group in the photograph.

The embossing on this piece of work consists in the striking up of the three beveled edged bosses *AAA* in the body of the crescent and the offsetting of the two ends from that body by an amount indicated by the dimensioned drawing, Fig. 431.

The construction of punch and dies is simple enough to require little

description, as the principal features are well shown by the photograph, Fig. 432. The bottom of the die seat, which is bored out in a piece of tool steel, is lined with steel ring sections to form the die thickness at the

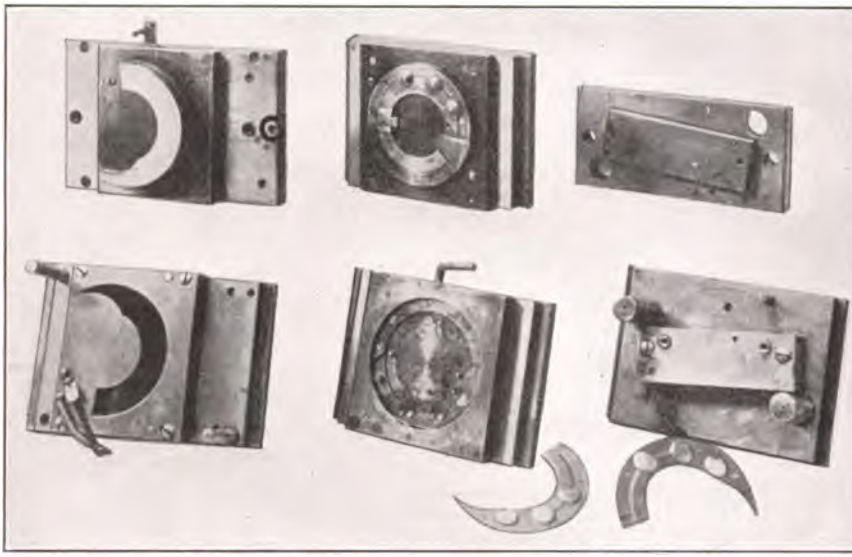


FIG. 432. — Blanking, piercing and embossing series for a coin register part

points where the offsets are desired, and corresponding sections made the reverse of the die members are fitted into the punch proper as shown. The round bosses forced up from the surface of the metal are formed by bevel head studs of hardened tool steel seated into the face of the punch plate and operated against similar depressions bored and countersunk in the chamber of the die. The die base is provided with a knockout in the form of small pins operated by the handle at the front which enables the work to be ejected with convenience after it is struck up.

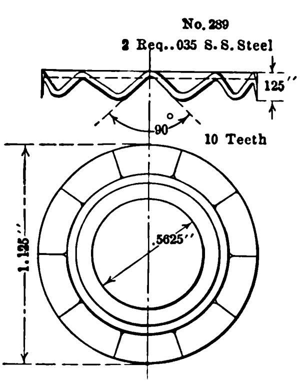


FIG. 433. — Embossed disk

The dies at the right in the photograph receive the embossed blank and pierce two small holes through near the ends as indicated in the blueprint.

TOOLS FOR A RING

The ring in Fig. 433 is embossed or formed with a series of radial V depressions and rises, the work being struck up between the dies in Fig. 434 at the left-hand side. The other dies at the right accomplish the

previous operations of piercing and blanking the ring progressive-die fashion. The center hole being pierced at this time provides a method of locating the work in the embossing dies by slipping it over the pilot in the lower die center. The upper and lower dies are alike except for the one having a pilot and the other a bore corresponding in diameter. The two

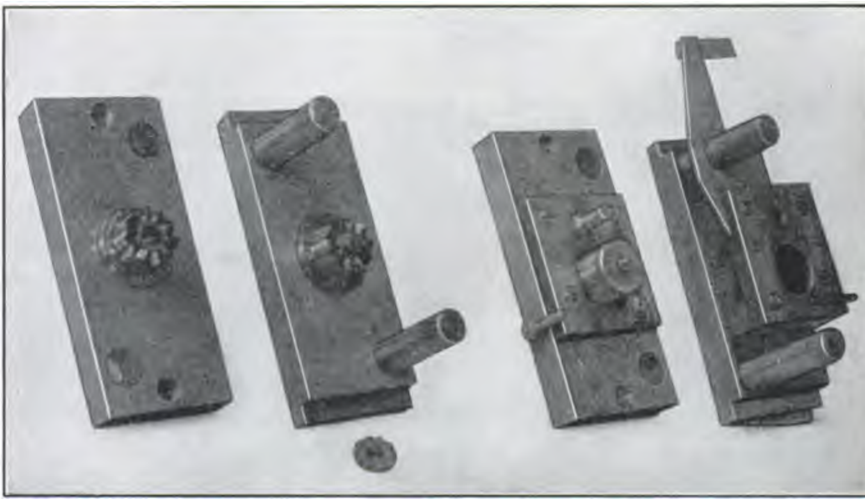


Fig. 434. — Ring embossing tools

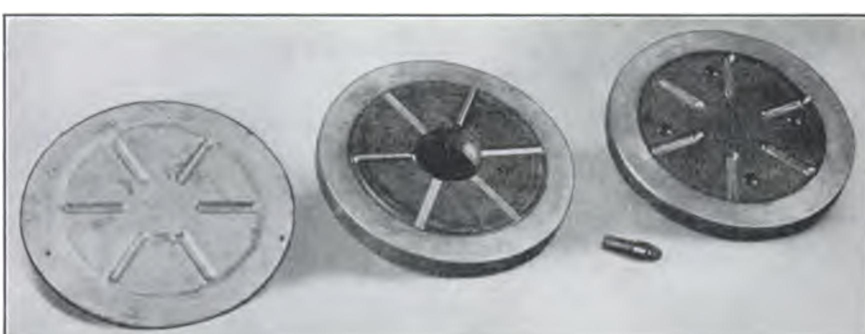


Fig. 435. — Embossing dies for a disk

dies are turned and milled and finished and hardened and then secured to the die base and upper holder, by means of fillister head screws and dowels in the flange around the die.

Embossing an Aluminum Plate

The engraving, Fig. 435, illustrates a set of simple dies for embossing radial ribs along the bottom of an aluminum disk like the one seen to the left in the photograph. The feature of interest here is in relation to the

manner of making up these tools. In the case of the die proper with concave channels running toward the center, the method of machining was to use a formed end mill and index the die on the dividing head of the miller. The punch plate or upper die was built up with convex faced sections of the right thickness and radius which were fitted into radial channels and secured there as integral parts of the die.

A Large Set of Dies

The dies in Fig. 436 are one of a number of similar sets used for ornamenting and strengthening the edges of certain sheet metal receptacles by embossing a simple design around the surface of the rings. The dies

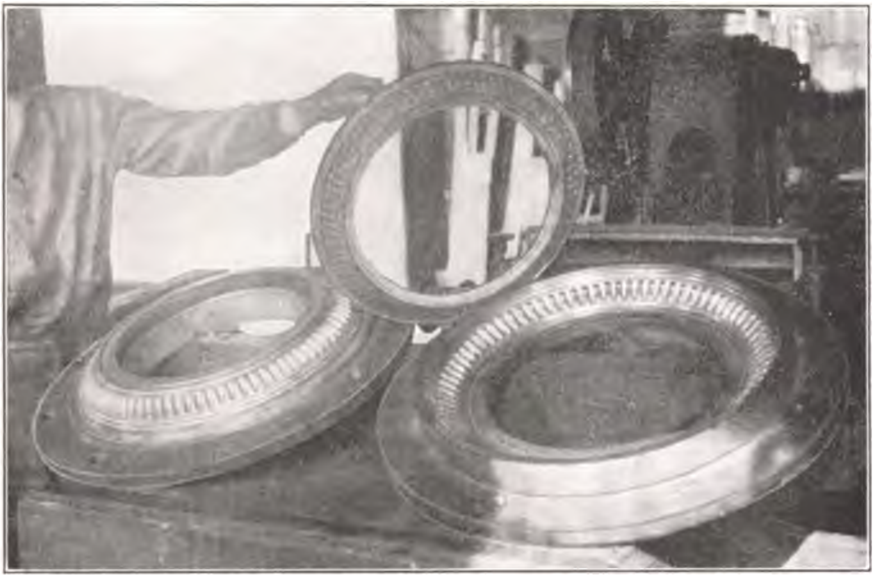


Fig. 436. — Large embossing dies

for this work are cast to form and finished up by filing, scraping, etc., to bring the embossing portions to sufficiently close relationship to one another to answer the purpose for which they are designed. The die metal is a close grained iron which when poured gives a smooth surface without serious pitting or roughness of any kind.

A Stamping or Marking Die

In Fig. 437 is an illustration of a set of dies for stamping the numerals on the face of the front cover of a calculating machine which give the positions for the setting dials. Fig. 438 shows the work to be a brass plate 0.040 in. thick, which is blanked out a little more than 5 in. square and

then stamped under the tools described. In the blanking operation the nine slots are punched out 3 in. long by $\frac{1}{16}$ in. wide, leaving a width of stock about $\frac{3}{16}$ in. for the stamped numbers.

The punch is made up of nine rows of figures from 0 to 9, the characters in each row being engraved on a solid block so that there are nine of these

FIG. 437. — Dies for stamping numerals

stamp blocks with 10 characters each. The body of the block in which they are fitted is planed out to receive them as a snugly assembled unit, and their ends are locked by clamps, setscrews acting against the ends

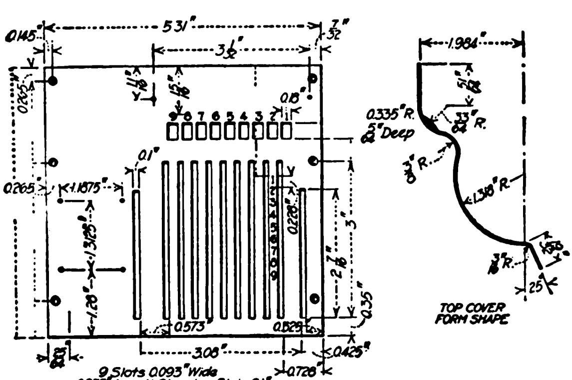


FIG. 438. — The stamped and formed plate

and the sides being placed in the block to set the whole group of stamps up tightly.

The rear ends of the stamps, or figures, rest upon a hardened and ground steel plate in the punch block, which resists the pressure of the 90 characters when they are forced into the work. Similarly the base of the die is of steel hardened and ground to back up and support the work when struck with the punch.

It has been estimated that if this combined punch with its 90-figure stamps were to be operated under the usual power press or in a manner similar to the handling of a coining job, a pressure somewhere between 150 and 175 tons would be necessary to stamp the entire set of characters properly into the plate. These tools are, however, not used in such a press, but under a drop hammer which is a homemade machine, giving satisfactory results with little outlay for equipment.

If the illustration of the dies, Fig. 437, is examined carefully, a guide plate for the work will be noticed at the left side and at the right two small clamps will be seen. There is an adjustable stop at the rear of the die

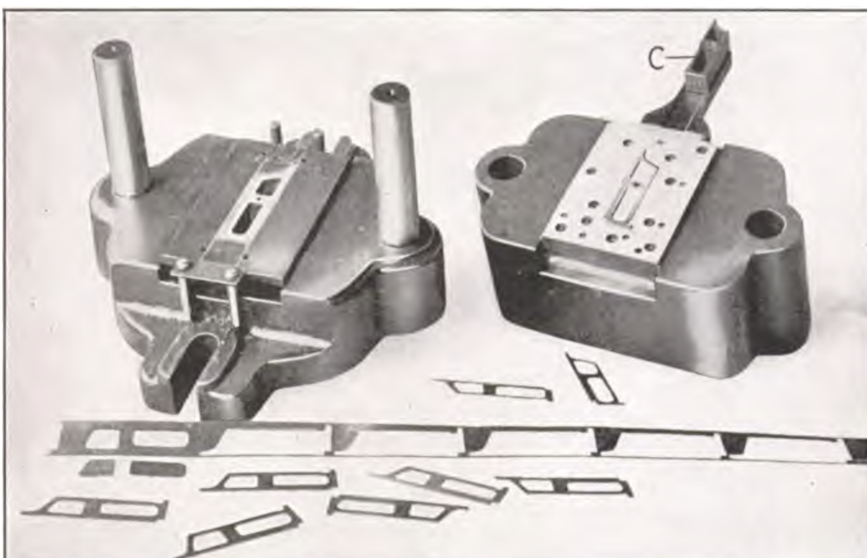


FIG. 439. — Blanking dies for typewriter type bar

base, and at the front is located another stop which confines the work edgewise so that it is properly nested and held all the way around.

While there are two clamp screws to turn up at each setting of a fresh piece of work on the die, this takes but a moment, and the entire operation of opening the die, setting the work, and operating the drop is performed easily and rapidly.

After the covers have been numbered along their slots they are required to be bent up to the general form indicated in the end view in Fig. 438, where the central portion with the slots and numbered sections is formed to an arc of about a quarter circle, and one flat portion at an angle with the opposite edge.

The brass plate, after it has been stamped and slotted, is annealed and

thus made ready for the forming process. This is carried on with a pair of simple dies made to the outline required and differing from each other only in that one is male and the other female, and the radii of the two are varied to allow for the thickness of the metal plate.

Preparing Type Bars for Riveting

This form of type bar is made of flat steel stock in the punch press with the aid of the dies in Fig. 439. The work consists in blanking the bar, punching out the center to lighten it, and piercing the central holes for connecting the mechanism by which the type bar is operated when assembled in the typewriter.

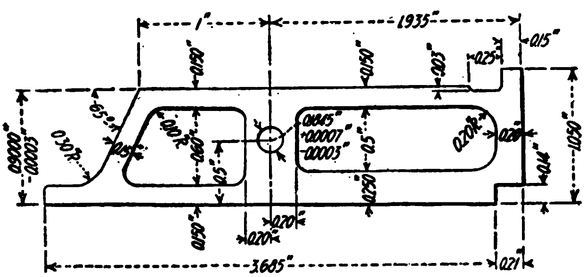


Fig. 440. — Detail of type bar

A detail of the blank is presented in Fig. 440. This drawing with the several blanks seen in the foreground of Fig. 439 shows clearly the unusual form of this type bar.

Referring to Fig. 440 it will be seen that the type bar blank is 3.685 in. long over all, has a height of 0.90 in. and a height over the rear lug of 1.050 in. The greater portion of the stock in the middle of the material is punched out to lighten the blank and this is done at the same operation as the blanking and piercing of the small rivet hole.

It will be noted in Fig. 439 that little waste is made in blanking these bars. The upper and lower dies are made in two sections, the dividing line being along the central hole in the blank. The dies are of the compound type; the lower member carries the outside blanking punch and the upper die carries the piercing punches for cutting out the interior of the blank. The top die is fitted with a shedder that forces the blank back into the scrap strip on the upstroke of the press. When the stock feeds forward again the strip carries the blank with it. The next down stroke of the press causes the projecting member at the front of the upper die, Fig. 439, to strike the blank, which is still retained by the scrap, and knock it out of the strip into a box.

This projecting "knock-out" is shown more clearly in Fig. 441, where the tools are set up in the punch press. The knockout is simply a block of

steel made in the form of the blank. As the strip of stock with the inclosed blank feeds under this, it merely presses down sufficiently to press one blank after another from the strip of stock. The strip is carried through the machine, where it is broken up into comparatively short strips of scrap.

The blanking portion of the lower die is supported by springs and is normally flush with the face of the die, as indicated in Fig. 439. The centers of the blank punched out (see Fig. 440), when punched down

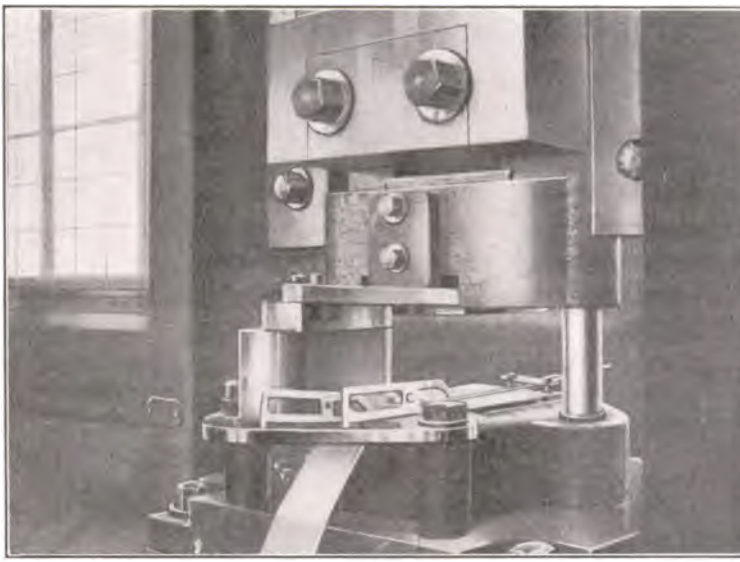


FIG. 441. — Type bar tools in the press

through the blank, fall through the holes in the lower die and out of the press at once, without being carried along by the stock. The arrangement of these supporting springs under the lower die, as well as the construction of the shedder for the top die, is of conventional type and needs no special description. It may be pointed out, however, that these tools are of heavy general construction, and the blocks on which they are mounted are equally well proportioned. The material handled is 0.028 in. thick and is tempered bandsaw steel, so that the material puts considerable work on the tools for the blanking of the type bar. It will be seen from Fig. 441 that a heavy type of press is used to operate the tools.

Following the blanking operation, the type bars are flattened and thus straightened from end to end. They are then ready for grinding to width and to length and to bring the front or working face truly perpendicular to the guiding bases, bottom, and top.

In the blanking of these type bars about 0.010 in. is left to grind off — 0.005 in. on each edge. Similarly, about the same amount is left at the

front end to assure this coming square with the upper and lower edges of the bar. The blanks are handled on the grinders, 130 of them held at a time in a single fixture, so that they are really ground exactly as a solid block of the same area would be gone over by the abrasive wheel.

The fitting of the type to the end of the type bar is an important operation, involving some interesting methods and fixtures.

There is, however, one more point to this operation which it may be well to describe in connection with what has gone before in reference to making these type bars — namely, the piercing tools for the three holes

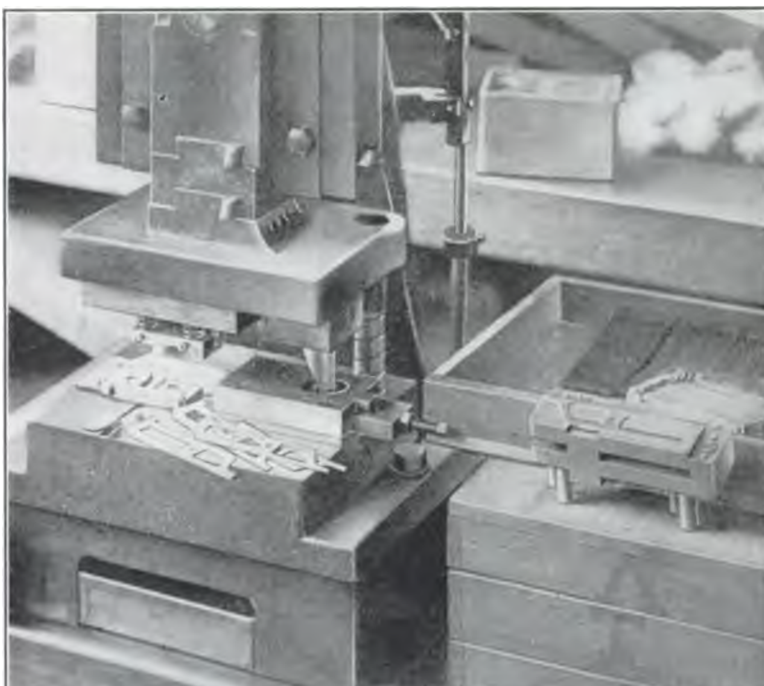
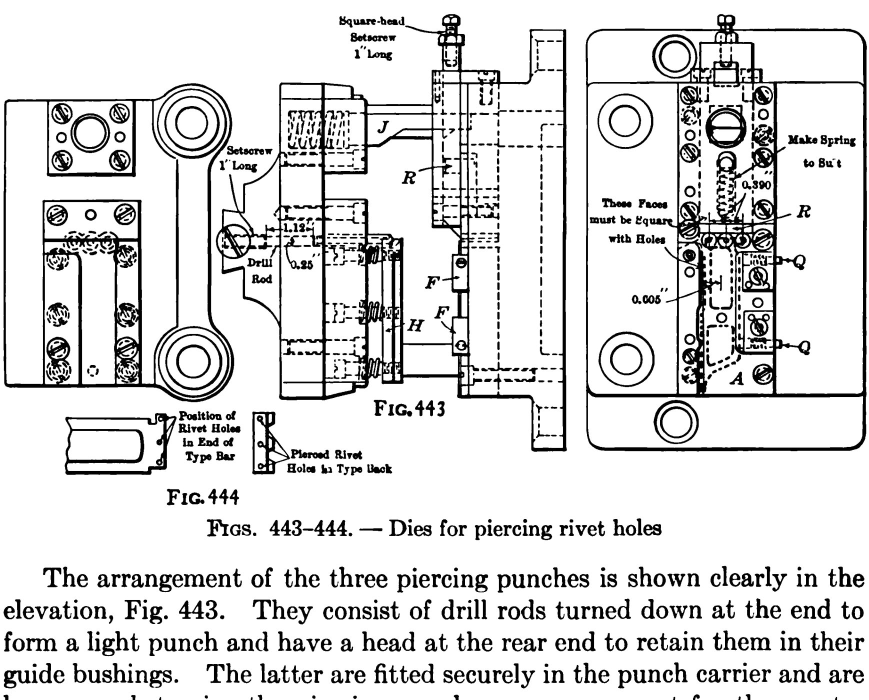


FIG. 442. — Piercing holes in end of type bar

at the front end of the type bar, to receive the rivets for later fixing the type in place. The piercing tools, Figs. 442 and 443, used in conjunction with the tools for making the corresponding holes in the type body proper, assure the type being so fixed upon the end of the type bar that it can never be displaced or loosened in any manner.

The method of nesting the work will be apparent, as it is here shown with the lower, or bearing, edge pressed against the stop guide at the back by the two spring punches QQ, which apply sufficient pressure to hold the blank in nest A, and against the top surface without likelihood of springing.

The endwise position of the work relative to the dies is determined accurately by the slide *R*, which is pressed forward against the action of the pressure spring by the taper plunger *J* carried by the punch block. In Fig. 442 this punch block is seen descending, and the taper plunger is about halfway down. Just before the piercing plungers have reached the work, the taper plunger brings a straight portion of its body against the rear end of the slide *R*, Fig. 443, holding this in position and consequently holding the work at the exact point for piercing the three holes at a definite distance from the front, or working, end of the type bar. This position, being the work of the combination slide *R* and the plunger *J*, is further aided by the pressure pad *H*, which is forced down on the work and holds it steady during the lift of the punches.



FIGS. 443–444. — Dies for piercing rivet holes

The arrangement of the three piercing punches is shown clearly in the elevation, Fig. 443. They consist of drill rods turned down at the end to form a light punch and have a head at the rear end to retain them in their guide bushings. The latter are fitted securely in the punch carrier and are long enough to give the piercing punches proper support for the greater portion of their length. Immediately behind the head of the piercing punch is a short plug about $1\frac{1}{8}$ in. long, of $\frac{1}{4}$-in. diameter, and behind this is the head of the screw. It is therefore an easy matter to adjust the punch to strike the work at the desired instant, and the three punches can be staggered for giving the shearing action as desired.

The method of setting the guide bushings will be apparent upon inspection of the plan view and the accompanying elevation, showing the two members of the press tools, Fig. 443, so that little further explanation

will be necessary. These tools are, of course, guided by pillars, so that they are operated similarly to subpress tools.

Referring to Fig. 442, an interesting gaging device is shown at the right upon the stand, this being the test gage, not only for the accuracy of the type bar itself, but for testing the placing of the rivet positions relatively to the front end and to the bottom of the bar. This gage has a nest at the top, made to accurate outlines to correspond with the blank itself and with location holes corresponding to the rivet holes and the larger holes pierced near the center of the type-bar blank. This nest is formed on the top of a pad that operates against spring pressure. The test is to place the blank upon the nest pad and push the whole thing down

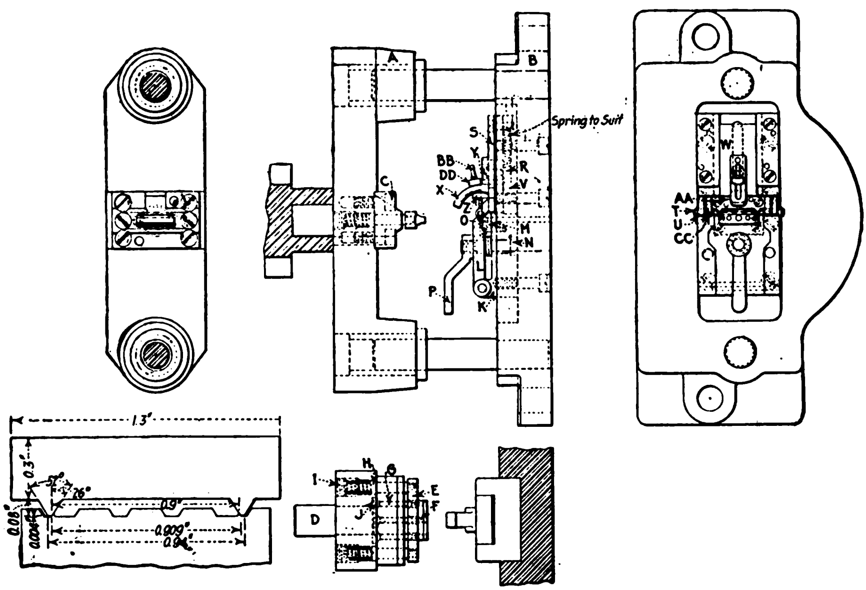


FIG. 445. — Details of type piercing dies

to see if the outer edges at the bottom and ends will just slide past the corresponding shearing edges of the test-gage body. This corresponds closely to what might be called the thumb-nail test, as commonly applied in the case of a flush pin gage, where the thumb nail is passed over two edges supposed to be flush and where a fraction of a thousandth discrepancy is easily detected if there is any lack of uniformity. Such is the case here. If the end of the type-bar blank or if the lower edge should project at any point by even 0.0001 in., this would interfere with the punches descending if pressed lightly with the finger.

The piercing tools for the type take care of all of the type for the machines and must therefore be adaptable to conform to the various angles to which the bodies of the type are milled in relation to the printing faces

of the characters. In Fig. 444 a sketch is reproduced showing the position of the small rivet holes in both type bar and type, and in Fig. 445 is a detailed drawing of the dies for piercing the holes in the type. The adjustable locator *DD* takes care of all angles of type and the work is held securely in its nest by the clamp *B.* It is not essential to enter into a detailed description of this die but its features are called attention to, as worth study by those designing adjustable tools for various classes of work.

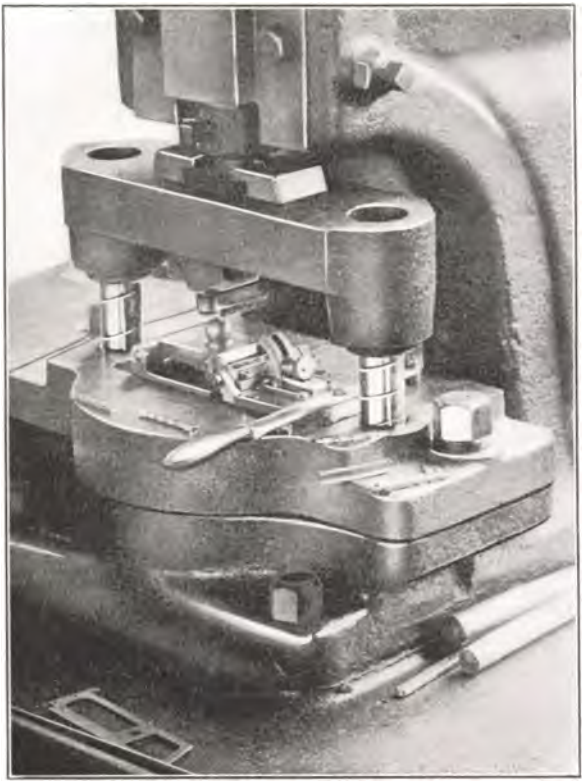


Fig. 446. — Piercing for type rivets

The dies are shown in operation in Fig. 446.

The important part of many riveting undertakings is not the actual riveting process but the preparation in the piercing of the holes for the rivets. The riveting tools are as a rule very simple devices, many examples of which are included in the half tone, Fig. 27, in Chapter I. With holes properly pierced so that they aline and with suitably formed rivets the riveting dies present no difficulties in making or using. For various examples of different shapes of riveting tools the reader is referred back to the above illustration.

A Set of Riveting or Staking Tools

The three steel parts in Figs. 447, 448, and 449 are members of a coin wheel that are made in the dies, Figs. 450, 451, and 452, and assembled and riveted or staked by the tools in Fig. 453.

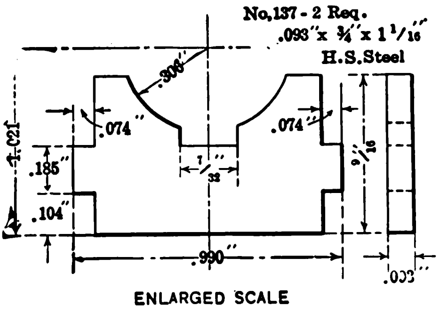


Fig. 447. — Spacing piece for a coin wheel

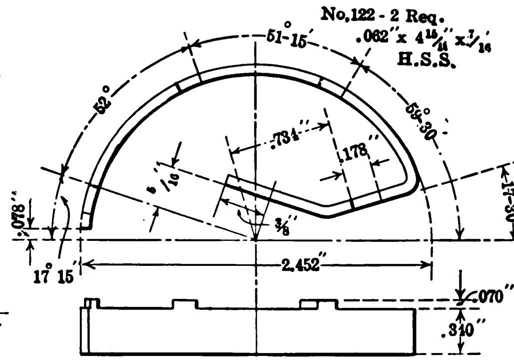


Fig. 448. — Coin wheel member

The blanking dies in Figs. 450 and 451 are of simple form and the blanking and piercing tools for the disk, Fig. 449, are of the progressive

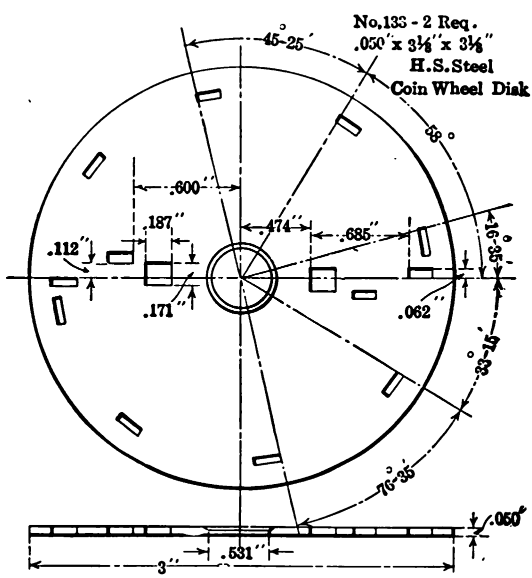


Fig. 449. — Coin wheel disk

type as shown by Fig. 452. The long blank, Fig. 451, is bent up to the outline, Fig. 448, by the hand forming tools at the right in Fig. 451. The tools by which the parts are fixed together in Fig. 453 are made up of a base *A* with an open nest for the dial which rests therein after the riveting

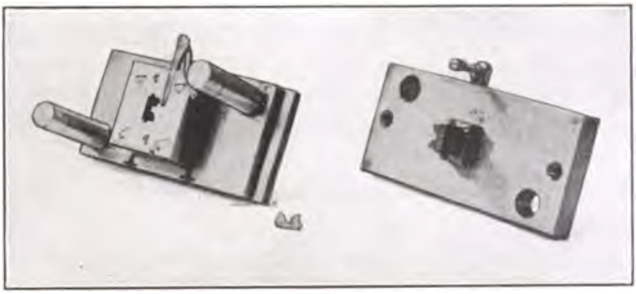


FIG. 450. — Blanking dies for piece Fig. 447

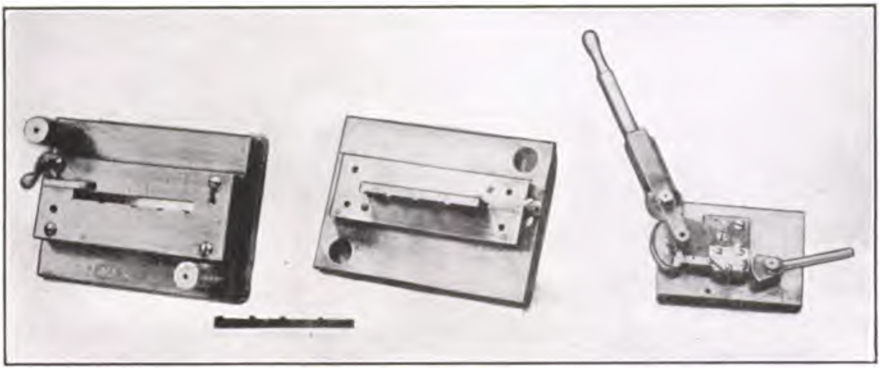


FIG. 451. — Blanking and bending tools for work in Fig. 448

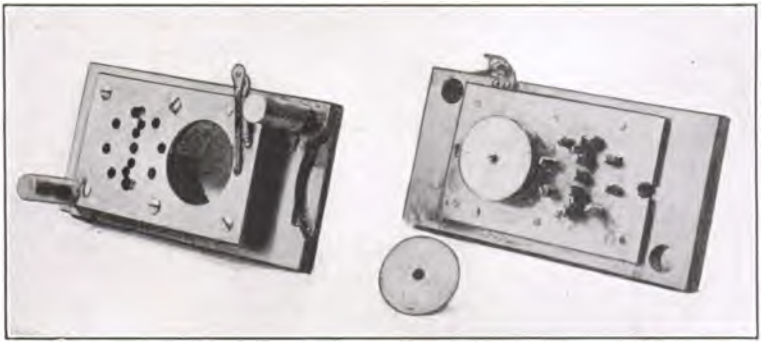


FIG. 452. — Blanking and piercing dies for coin wheel disk Fig. 449

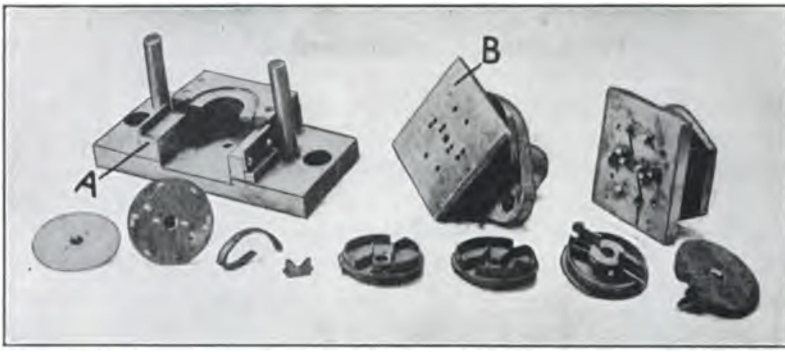


FIG. 453. — Riveting dies for coin wheel

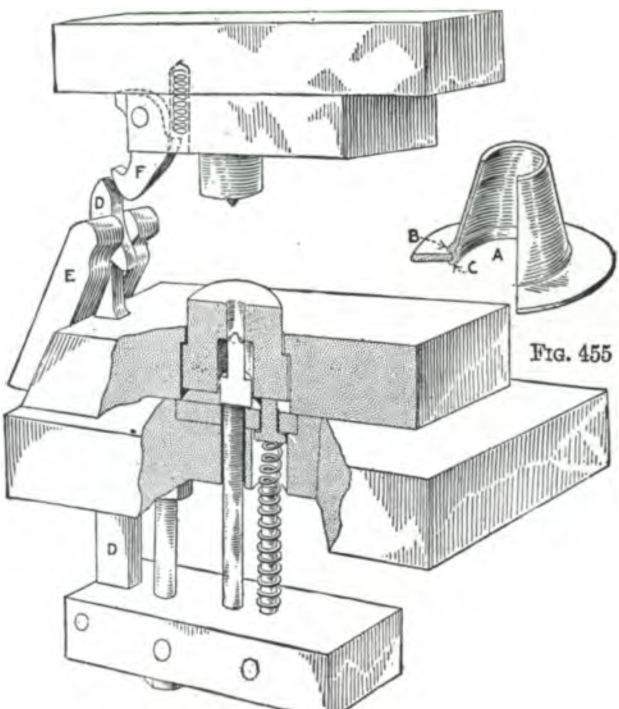


FIG. 455

FIGS. 454–455. — Swaging dies

lugs on the other members have been placed into the pierced slots in th· disks. The partially assembled wheels are shown in front of the tools and the arrangement of the riveting punches in the holders will be understood from the engraving. These punches are made with V-shaped points to strike the end of the lugs and spread them sufficiently to hold the parts together. The punch holder carries a pressure pad *B* to hold the work while the operation is performed.

Swaging Dies for an Air Rifle Part

The die shown in Fig. 454 was made for producing the shot seat A, Fig. 455, for an air rifle. Brass tubing is used $\frac{1}{4}$ in. outside, a little under $\frac{3}{16}$ bore and the washer hole is made slightly over $\frac{1}{4}$ in. With a circular saw the tubing is cut $\frac{37}{64}$ in. long and then the pieces are tumbled. As can be seen from Fig. 454, the die upsets the wall of the tube, increases and tapers the outside diameter, and forms a choke bore about $\frac{11}{64}$ in., leaving

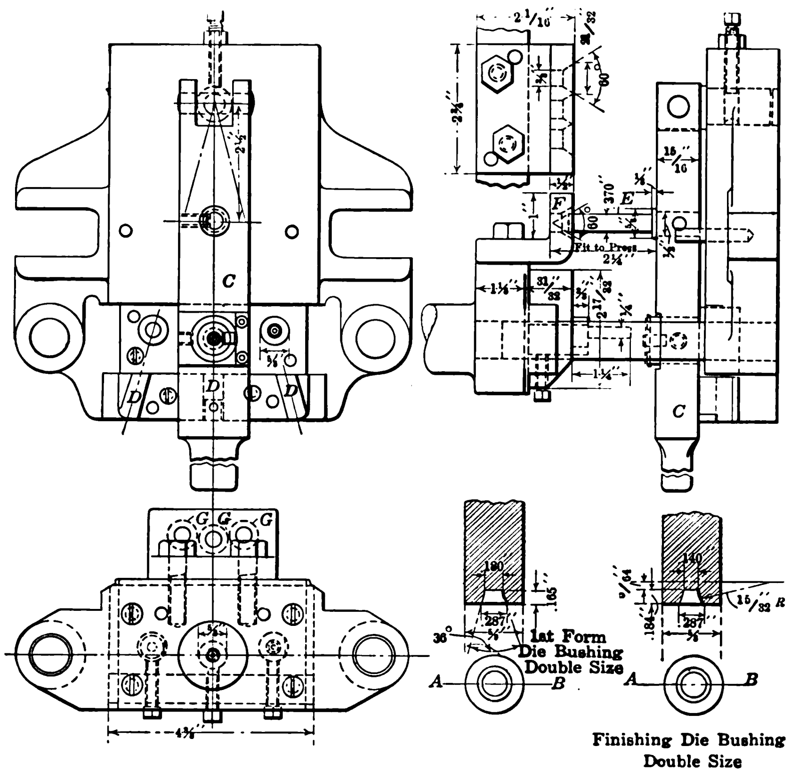


Fig. 456. — A forming die for a brass tube

the outer end tapered to hold the shot; besides throwing up a bead at B and turning over the lower end, thus securely seating the tube in the washer.

The construction of the die is shown in Fig. 455. The springs hold up the die and also return the knockout. In operation the washer and the tube are assembled and placed in the die, the tube resting on the knockout pin, which also acts as a mandrel to form the funnel-shaped mouth, and the washer resting on the die. The $\frac{1}{8}$-in. motion of the die keeps the washer in the right position on the tube while the latter is being upset. The die is countersunk at the top to form the bead over the washer.

On the downstroke the dog *F* swings in and passes *E* and *D*, but on the upstroke it engages the hook *D* and pulls out the finished piece; as *F* is wider than *D*, *E* pushes it out of engagement with *D*. The die being tapered, the only resistance that the knockout has to overcome is right at the beginning of the pull, when the dog is in full engagement with the hook. At the point of release the only stress is from the pair of light springs, so that the wear on the points is nominal.

Swaging a Small Bushing

The dies in Fig. 456 are for swaging or forming the ends of the small tube shown in Fig. 457, where *A* is the blank and *B* the swaged product.

The drawing, Fig. 456, shows two dies for swaging down the tube ends.

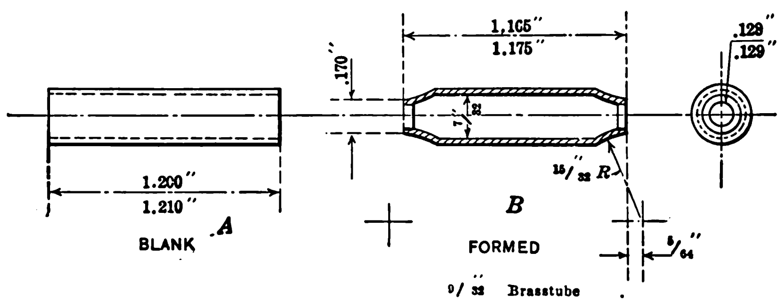


Fig. 457. — Tube swaged at ends

The first gives a straight taper, the other forms a curved end. The work is placed in the swiveling holder *C* swung to the right for the swaging of the taper end, moved to the center for the next blow which swages the curved outline, and then swung to the left for the knockout punch to push the work down out of the dies. The swinging holder *C* has a locating tongue to fit the index slots *DDD* at the front of the die base. In addition, alinement with the upper dies is assured by the cone pointed pin *E* which enters a guide hole in the bracket *F* attached to the rear of the upper head. There are three of these guide bushings, as shown at *GGG* in the plan view. They are, of course, located upon an arc struck from the same center as the pivot which carries the swinging work holder *C*.

CHAPTER XIII

INDEXING AND TRANSFER DIES

The processes of piercing, notching, graduating, drawing, etc., are often carried on in the press by the aid of some form of indexing die or, again, by a transfer tool which shifts the work from one position to the next with marked advantage in one way or another over the usual hand method of placing the blank as required.

A few typical forms of such devices as incorporated in the dies themselves are illustrated briefly in the present section. The first of these is shown by Fig. 458 which represents a notching device for disks for electrical work. This is one of the commonest forms of indexing die, as num-

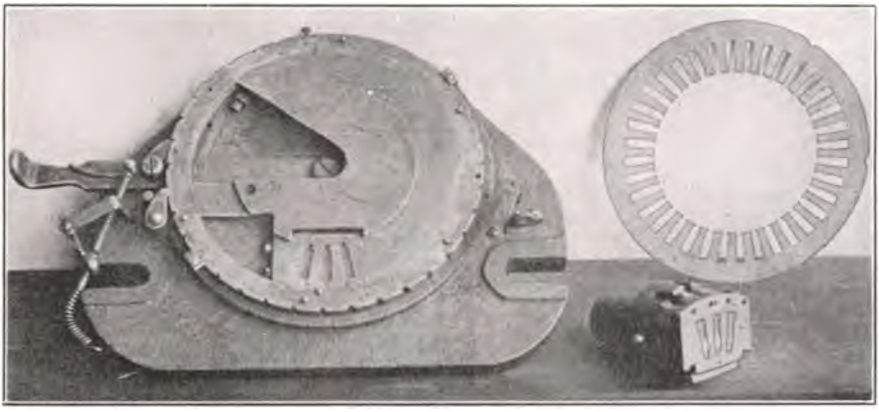


Fig. 458. — Indexing die for notching disks

bers of similar tools or dies operated on the same general principle are used for this class of work.

This particular set of dies pierces three slots at each stroke, the punch being a triple device as indicated. It might, however, be a single punch or the holder might carry more than two or three according to conditions. So far as the punch is concerned, it may be stated that it carries a stripper which is backed up by a rubber buffer and the punch sections are let into a steel holder which is made with a round shank to fit the slide.

The die is located at the front side of the indexing dial and the latter is in the form of a ring with gage pins which enter notches in the edge of

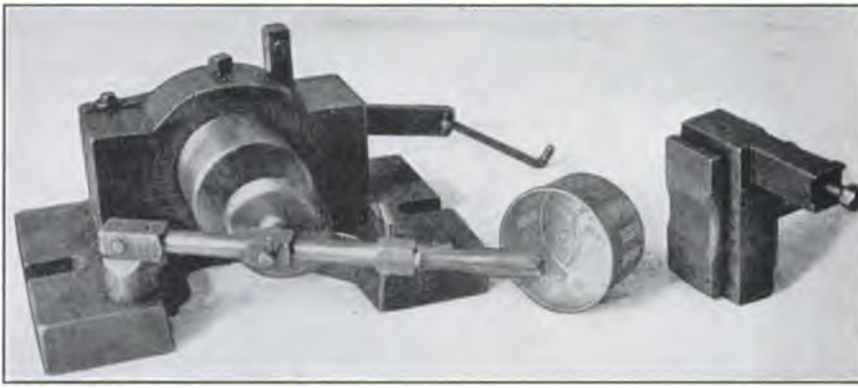


FIG. 459. — An indexing perforating die

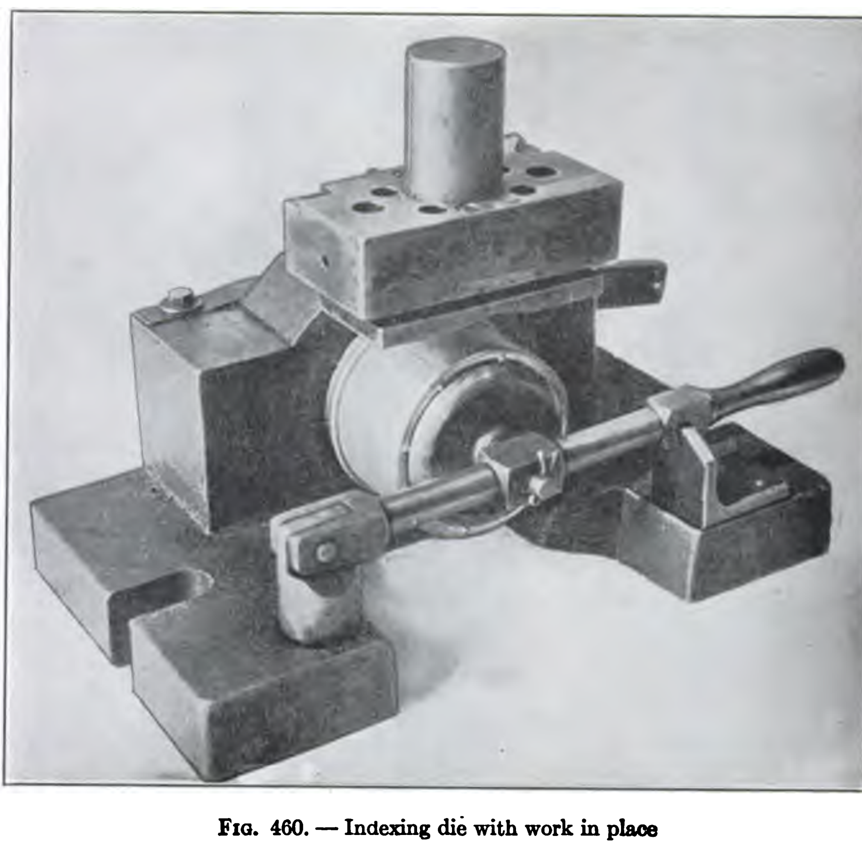


FIG. 460. — Indexing die with work in place

the work to locate the disk and cause it to rotate when the index ring is advanced by the ratchet teeth and pawl at the side. There are two pawls at the left side, one for feeding the ring ahead, the other for locking it against backward movement when the feed pawl is being swung to the rear, preparatory to giving the indexing ring its next forward movement

An Indexing Perforating Die

The indexing tools in Fig. 459 are for perforating the aluminum article at the center, through the side walls, with groups of small openings, numbering 48 holes in a group and 16 groups or 768 holes in all. The

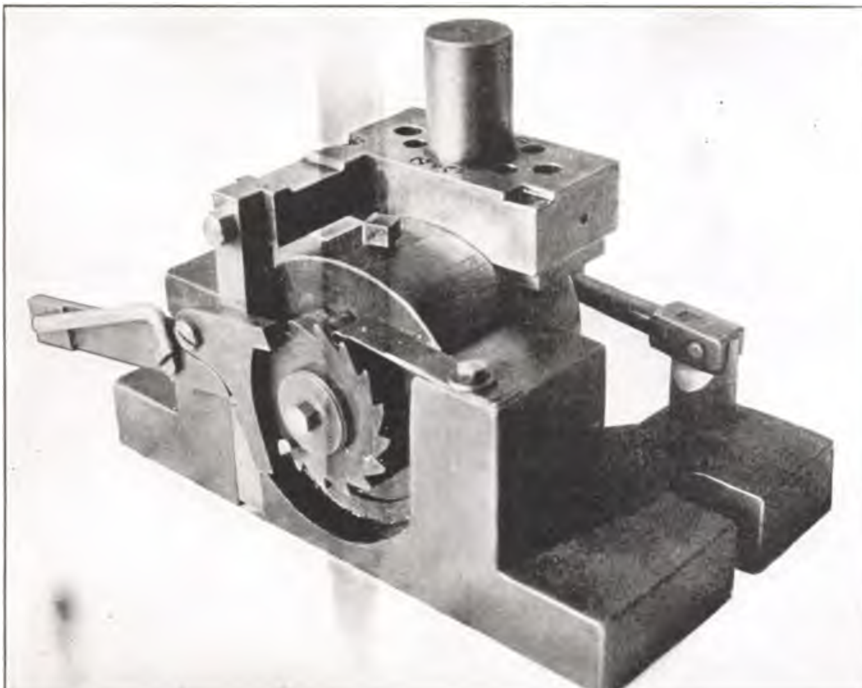


Fig. 461. — Mechanism at rear of indexing die

punches are placed, 48 of them, in a punch plate fitted to the holder at the right and a close fitting stripper is mounted on the holder in the manner indicated. The work is shown in place on the index plug in Fig. 460 and in Fig. 461 the method of arranging the punch holder to actuate the index mechanism will be seen.

The bottom of the work has been perforated in an earlier operation and here there are three pins in the end of the index plug that enter three holes pierced in the work and act as drivers for the piece. The lever at

the front with the large disk attached is swung around and latched as in Fig. 460 to hold the work on the fixture. The die is in the form of a horning die with diameter to fill the cup and the outer shell fixed to hold the die which is fitted into it along the top center line. The rotary part is an internal plug or arbor that carries the three driving pins as described before.

When the ratchet wheel is actuated by the pawl at the rear, Fig. 461, the arbor with the work is rotated ahead one notch and the work thus brought into place for the piercing of a fresh group of holes. The pawl is carried upon a slide at the back which is actuated by the up and down movement of the press. A stop pin in the face of the ratchet wheel acts to release the feed pawl upon the completion of one revolution of the work.

Notching a Comb

The detail in Fig. 462 represents a typewriter comb which is notched in the indexing die shown by Figs. 463 to 466. The work is made from phosphor bronze 0.032 in. thick and is bent up to a circular channel with

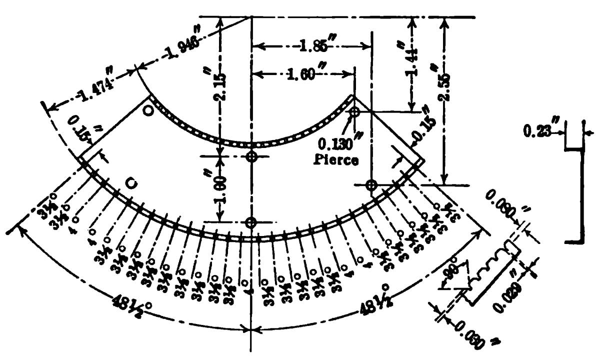


Fig. 462. — Typewriter comb

an outer radius of about 3½ in. There are 28 notches cut in the flanges around this arc shaped piece and these are spaced in accordance with the angular measurements given on the drawing.

The indexing fixture is shown clearly in the photographic views, the first of these, Fig. 463, illustrating the working face of the holding fixture in position on its spindle and the machine ready for operation. The appearance of the comb before and after this punching operation is well brought out in Fig. 463, while the principal dimensions are included in Fig. 462. The details of construction of the fixture are shown in Fig. 466. The general method of operation will be obvious upon examination of the various illustrations.

Referring to Fig. 464, which shows the work-holding plate removed, it will be seen that the inner face of this plate is provided with a seat in the form of an arc, into which the work is slipped and in which it is lo-

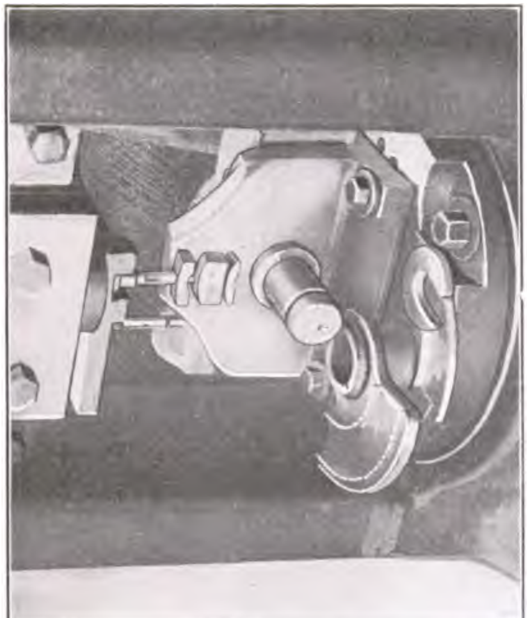


Fig. 464

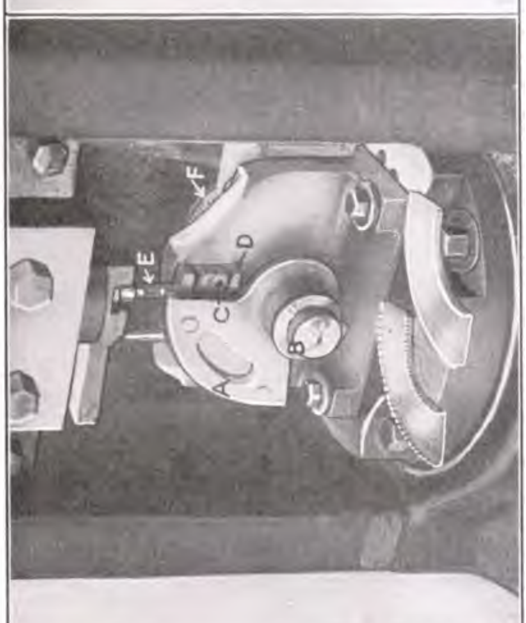


Fig. 463

Figs. 463–464. — Indexing die for notching a typewriter comb

cated endwise by suitable stop pins that hold it in place. When the work plate, *A*, Fig. 463, is put back in place on the spindle, it is held against longitudinal movement by the open washer *B*. This slides into a slot in the circumferential groove near the end of the spindle and the projecting

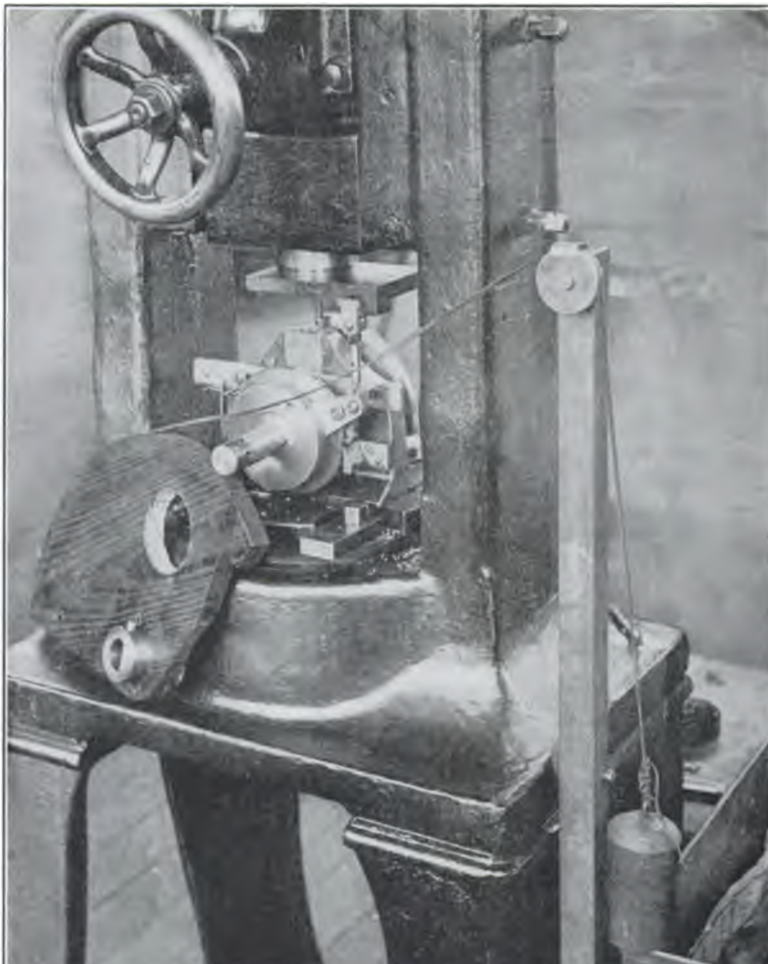


FIG. 465. — Rear of notching die

flanges of the work, which are to be notched, rest upon the curved surfaces at *CD*. These are more clearly seen in Fig. 3 which shows the work holding plate removed.

The punch *E* is a cylindrical body with two cutting teeth inserted at proper distance, one above the other, to operate upon the two flanges

simultaneously. This punch is illustrated in Fig. 464. At the left of the punch will be seen the mechanism to operate the pawl by which the ratchet wheel at the rear of the fixture is moved upon the upstroke of the punch. This advances the work one space farther ahead for the cutting

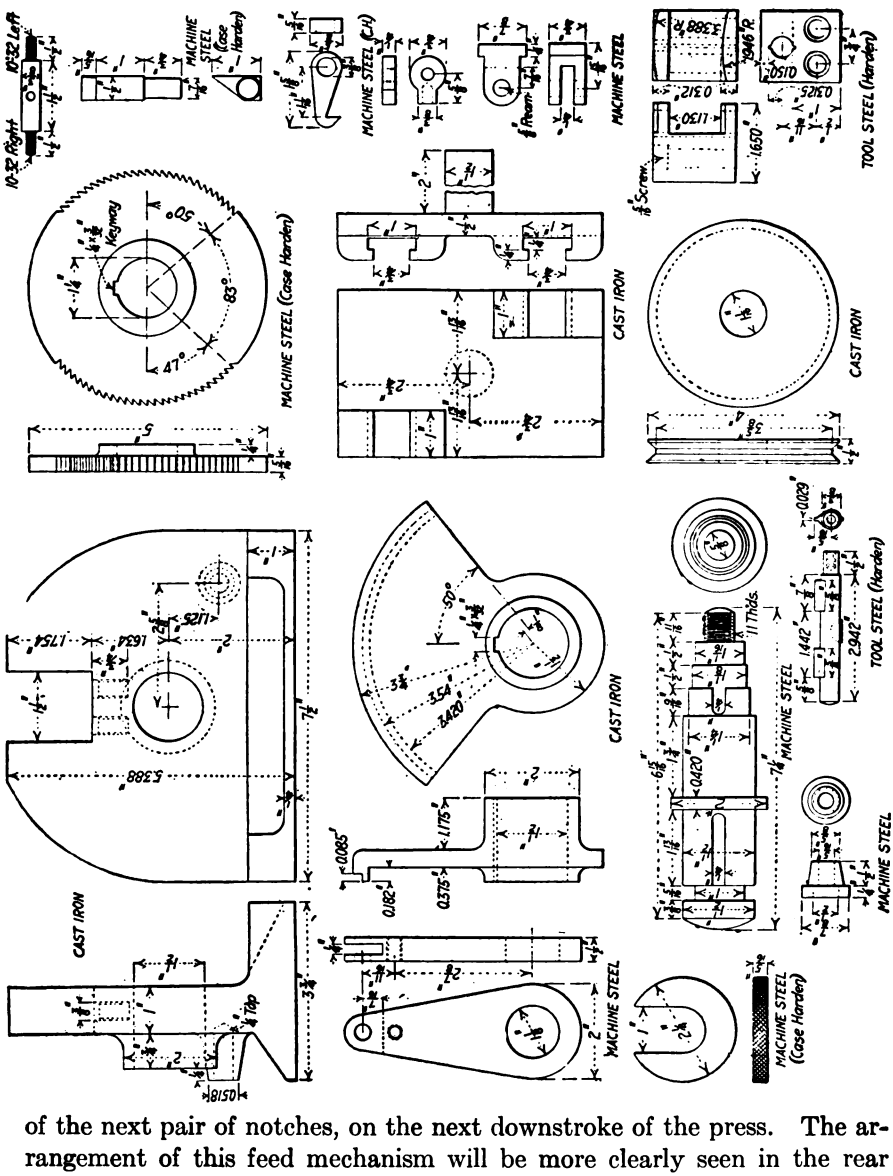


FIG. 466. — Details of comb notching die

of the next pair of notches, on the next downstroke of the press. The arrangement of this feed mechanism will be more clearly seen in the rear view, Fig. 465. It will be noticed from this and from the details in Fig. 466 that the ratchet wheel is provided with two sets of teeth on opposite

edges. The fixture answers for both upper and lower combs by changing the ratchet wheel.

The details of the punches also are shown in this drawing along with the guide and supporting blocks for the curved edge of the work. The details show also the form of the spindle for mounting the work and operating fixtures, as well as the various smaller parts that enter into the construction of this device.

It should be noted that the work holding fixture, which is in the form of a quadrant, is made with a long hub to pass over the spindle. Although this is easily slipped into place, the bearing is sufficiently long to give it a firm position upon its support. This makes the notching process free from chatter and during the indexing the work is held steady for the punching stroke.

The punch holder is novel in construction in that it is provided with cross slots to receive the flange on the head of the punch and allow the

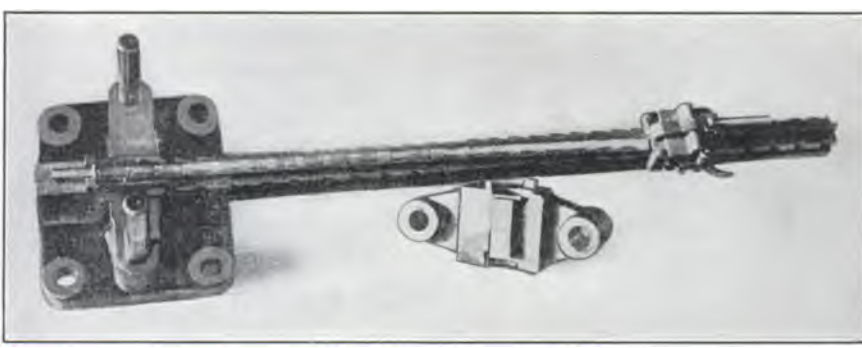


FIG. 467. — Dies for graduating a straight bar

punch to be adjusted as required. Similar means are used for mounting the plunger that operates the indexing devices. This device is operated at the usual rate of the punching press, and it takes less than a minute's time to produce the complete series of 28 pair of notches.

Referring now to the punch *E*, Fig. 463, this will be seen to be of novel construction. It has a body which is about $\frac{3}{8}$ in. in diameter and which slides in a guide of the same size. The punch body is fitted with two cutting blades, each about $\frac{5}{8}$ in. long, and spaced longitudinally 2 in. apart so that they strike the outer and inner flanges of the work simultaneously.

These cutting blades are also adapted to form the angular portion of the opening at the top of the notch, which is formed to 90 degrees so that the cutting portions of the punch are similarly made at this angle. As indicated, the punch body is provided with a Woodruff key to prevent it from twisting in operation. The sleeve of the flanged head for securing

the punch in the punch holder is made to fit over the neck on the punch and is connected thereto by a screw, so that it cannot be mislaid.

The tools in Fig. 467 are for indexing a straight bar while numerals and graduations are stamped upon its surface. The punch operates in the usual fashion over the die and the work which is attached to the sliding carrier on the ratchet feed bar extending from the face of the die shoe, is fed forward a definite distance each stroke so that it assumes the correct position over the die for each graduation or character stamped upon its surface.

Transfer Devices

There are various devices on dies and arrangements for removing the work from one section to another, to obviate the necessity for the operator picking the piece up with his fingers and replacing it in some other

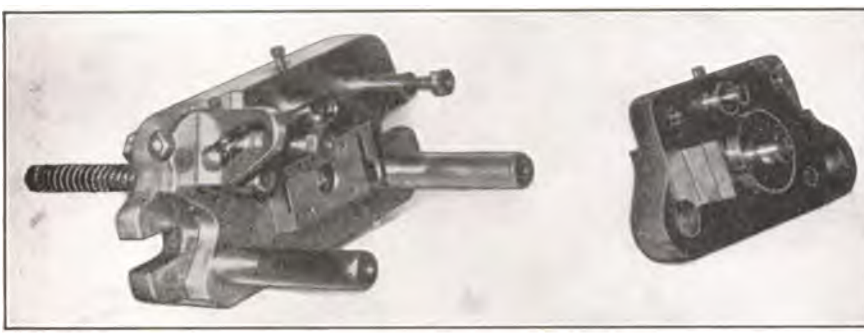


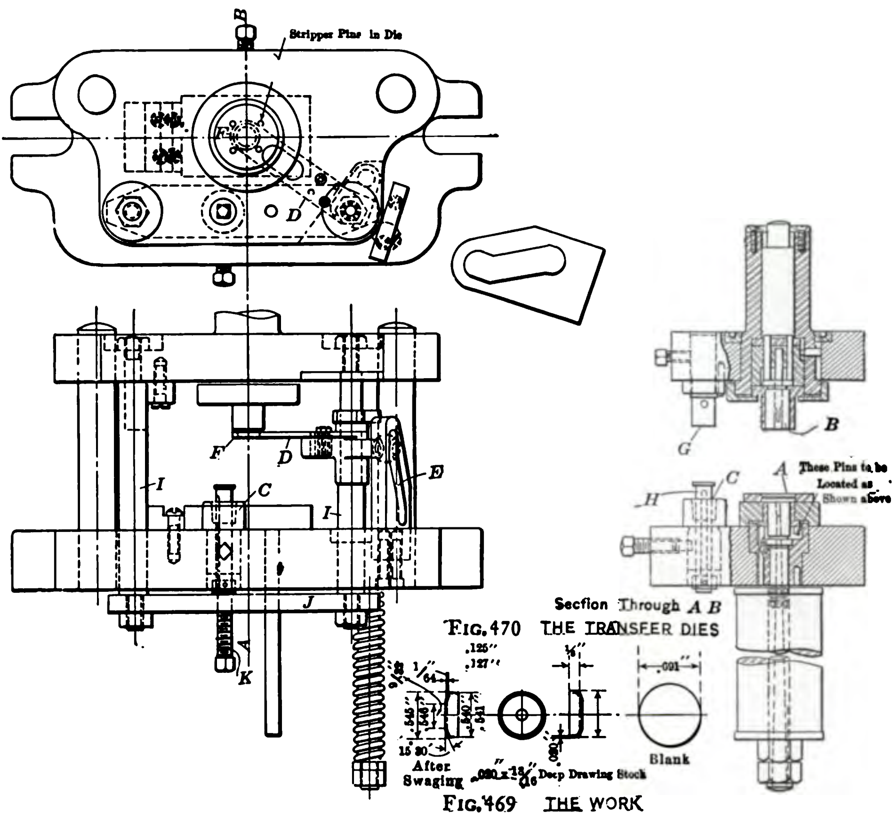
Fig. 468. — Transfer device for compound die

part of the die. An illustration of a set of dies arranged in this manner is shown in Fig. 468 which represents the method of blanking, drawing, and piercing a shell in a compound die and then transferring it automatically to a swaging die for reshaping the walls of the piece.

The work is shown in Fig. 469, and the construction of the tools in Fig. 470. From the latter view it will be understood that the blanking, drawing, and piercing are accomplished at one stroke in the dies *A* and *B*, which are of the compound type and so clearly shown as to be understood without definite reference to each feature. The shell emerges from these dies with straight walls and is transferred automatically to the die *C*, in front, where it is formed to a taper as indicated in Fig. 469. The operation of the device is as follows:

When the punch head and the drawing die *B* rise, carrying the shell up with the die, the transfer arm *D* is swung by cam slot *E* into line with the die and the positive knock out above forces the work down into the split opening in the end of the arm at *F*. On the down stroke this arm is swung

forward by the cam movement and alined with the swaging die *C* at the front of the shoe so that the punch *G* can force the work down into the tapering die *C*. The knock out in this auxiliary die is at *H*. It is depressed



FIGS. 469–470. — Transfer dies for a cup

by the forcing down of the shell into the die and when the punch head rises it is carried upward by the action of the bolts *II* and the cross bar *J* under the knock out screw *K*. This clears the swaging die *C* for the reception of the next shell upon the next down stroke of the punch.

CHAPTER XIV

THE SUB PRESS AND ITS DIES

The sub press which has been referred to briefly in the opening chapter of this volume is used advantageously in many lines of work, particularly where parts to be produced in the power or foot press are quite small, of thin stock, intricate in outline or of very close degree of accuracy. Owing partly to the fact that their range of sizes, as generally made, is somewhat limited, and also to the first cost as compared with the ordinary types of press tools, they are not so generally used as requirements would seem to justify in the average line of close manufacture; although on such work as clock and watch parts, meter parts, and numerous other lines of press work they are employed very extensively.

FIG. 471. — Overhang type of sub press

There are two general types of sub presses, the cylindrical and the pillar, each incorporating the principle, however, of a plunger sliding in a bearing which is attached to the casting that forms the base. The cylindrical type is illustrated by Fig. 471, the pillar type by Fig. 472. The latter of course is of the general design that has been so commonly adopted by die makers who have required a more accurate type of press tool than the plain open punch and die, and who have constructed tools of the general pattern of Fig. 472 for a widely diversified class of operations, not only on small parts but for large blanks as well; for this class of die has made it possible to secure a refined product, and even where no special degree of accuracy is required it has enabled press tools to stand up to their work for a greater period of time, and it has facilitated the operation of setting up the work in the press and simplified the problem of tool upkeep.

With the pillar type referred to, the guide pins may be either on the center line or at the rear of the die base; or the two pillars may be placed at diagonally opposite corners, or again four pillars may be employed, one at each of the four corners of the die. The location and number of pillars employed depends upon the size and shape of the die shoe or base. There is practically no limit to the size of the work that may be handled in such dies except the limiting capacity of the press itself. The various forms of construction differing somewhat in details and materially in dimensions have been illustrated in full in preceding chapters.

As a rule the pillar type of sub press has no provision for compensating for wear; but where an outfit of this character is to be used more or less continuously the pillars may be of hardened and ground steel, and the bearings may be bushed with the same material. The head or punch holder may be provided with a shank to fit directly in the slide of the press, or the shank may be discarded entirely and the punch holder secured to the lower face of the press slide by bolts passing through drilled holes at the ends of the holder and tapped into the press slide. Or again, some form of adaptor may be employed for connecting punch holder and press slide. These details have been covered in connection with various illustrations of dies presented in other chapters.

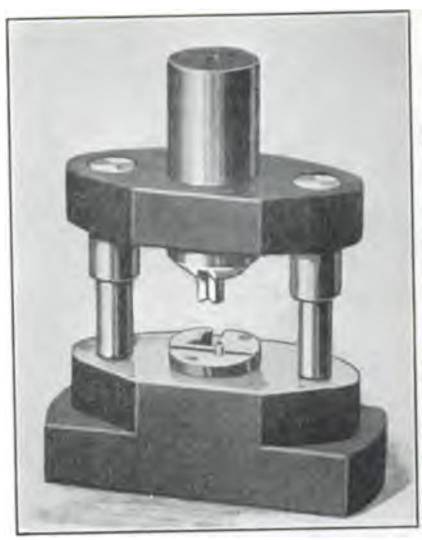


FIG. 472. — Pillar sub press

We have come ordinarily to call such tools "pillar dies" or "pillar type sub presses" and to apply the term "sub press" to the cylindrical or barrel form of die in Fig. 471. This sub press is made in two forms, the overhang pattern of Fig. 471 and the arch form which, as its name indicates, is built with an open arch frame which allows the stock to be passed directly through from side to side. This form of press is generally used for blanking dies, either simple, tandem (or progressive) or compound, as these dies usually work from the strip of metal. The overhang type is preferred for second operations where the blank must be placed individually in the dies, as for such operations as piercing, trimming, shaving, forming, and so on.

While, as already pointed out, cylindrical sub presses as manufactured are necessarily limited in their capacities, it will be of interest to note that they are regularly made with plungers that range in diameter from $1\frac{3}{16}$ in to 6 in.

From the drawing it will be seen that the sub press has a cylindrical plunger which slides up and down in a babbitted sleeve or bearing held in the housing or barrel by a cap nut at the top. The babbitt sleeve is tapered externally and fits a similarly tapered seat in the barrel, so that it admits of adjustment by means of the nut to retain a fit for the plunger without affecting the original alinement.

The base is finished with a shoulder or hub that is machined to fit the bored opening in the lower end of the barrel. As indicated in the drawing the upper end of the plunger terminates in a button which is machined to fit into a member known as a hook which is secured to the press slide.

Sub presses of this kind, when supplied without the dies do not have the base and barrel fitted to each other, for it is necessary that the base recess for receiving the punch or die, as the case may be, should be bored at the same setting as the outside of the shoulder or hub is turned to assure their being concentric with each other. It is customary for die makers to bore the opening in the lower portion of the barrel to assure its coming true with the plunger. When these members are once fitted together, they are of course fitted with dowel pins so that they may afterward be taken apart at any time and remounted without disturbing the alinement.

It is obvious from the foregoing that the cylindrical type of sub press has the marked advantage that its recesses for the die, punch and other members, can be bored true with one another more readily than in the case of other designs. It is true, however, that the usual design of press as used for the ordinary open die has insufficient height to admit the cylindrical sub press of standard dimensions, although builders now make lines of presses of suitable range for this form of sub press. Where such machines are not available, the pillar sub press is used.

The Dies of the Sub Press

Typical blanks produced by means of the sub press, and work for which this type of press is especially adapted, are illustrated by Figs. 473 and 474, the first of these representing a group of parts pierced and blanked by tandem or progressive dies, while the second engraving shows a variety of parts as manufactured in compound dies.

There are cases where plain blanks without holes or openings of any kind are preferably made in sub press dies, because of the positive alinement that enables the closely fitting punches and dies necessary for very thin work to be operated without shearing and with accurate results on the work.

The advantages of progressive dies and the additional advantages of compound tools have been discussed fully in other chapters and need

not be entered into here. It may be said, however, that these advantages are quite as marked in the case of the sub press tools. For if plain blanking or if tandem dies tend to produce blanks that are slightly distorted and which for the most accurate work have to be flattened in another operation,

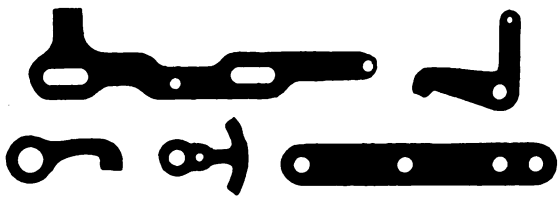


FIG. 473. — Tandem die work in the sub press

the compound die in the sub press will correct this trouble. And just as the progressive die will facilitate the production of blanks requiring piercing, so will the compound die perform the two operations as one, with entire accuracy between the contour and the position of the openings pierced, for

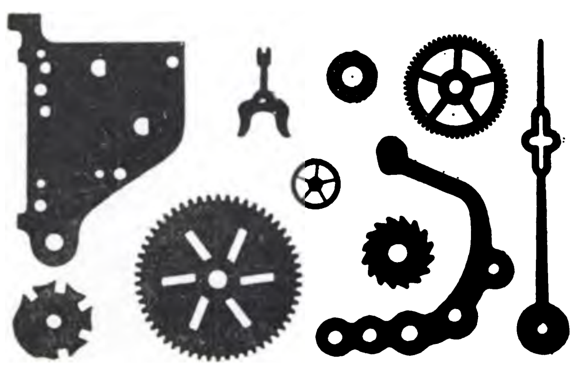


FIG. 474. — Compound die work in the sub press

there is no shifting of the work between the operations of piercing and blanking. Moreover, as regards compound dies, they will retain their size under numerous sharpenings much longer than other types of dies because of the reduced clearance angle made feasible by the fact that the work does not have to pass clear through, but is instead ejected by a knock out.

In Fig. 475 an arch type of sub press is illustrated with compound dies for blanking and piercing a wheel like Fig. 476. The blanking die is shown at *A*, the blanking punch at *B*. The piercing punch is located at *C* and the piercing die opening is formed at *D* in the center of the blanking punch *B*. The piercing punch is provided with a taper shank which fits a taper hole in the holder *E* and it is further secured by a small screw tapped in from the top.

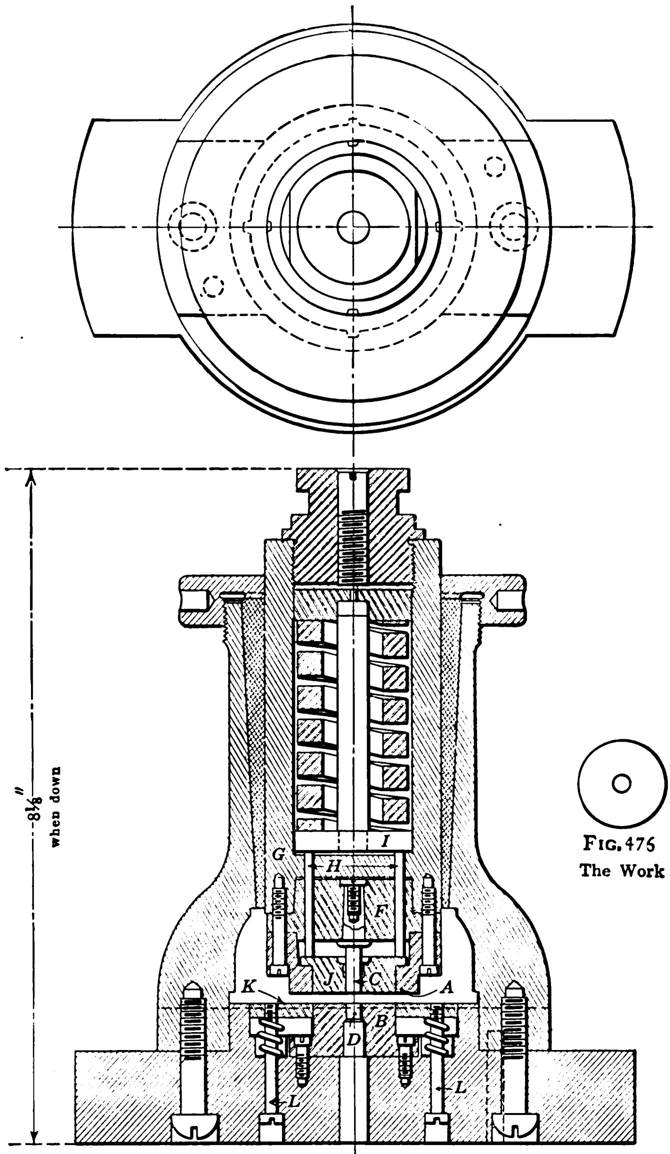


Fig. 476
The Work

Figs. 475–476. — Arch type of sub press

The punch holder *E* is fastened to the bottom of the plunger *G* by fillister head screws and it has a taper hub fitting deeply into a taper seat in the plunger end. This holder serves as a mount for the blanking die *A* which is located over a taper shoulder as shown and held by the same screws that pass through the holder *E* into the plunger. The holder *E* is drilled to allow the pins *H* to pass through into contact with the knock out *I* at the bottom of the spring chamber in the plunger. Adjustment of the spring pressure is made by means of the headless screw carried by the button at the top of the plunger. The pins *H* act against knock out disk *J* which ejects the blank from die *A* and forces it back into the scrap stock which carries it out of the press.

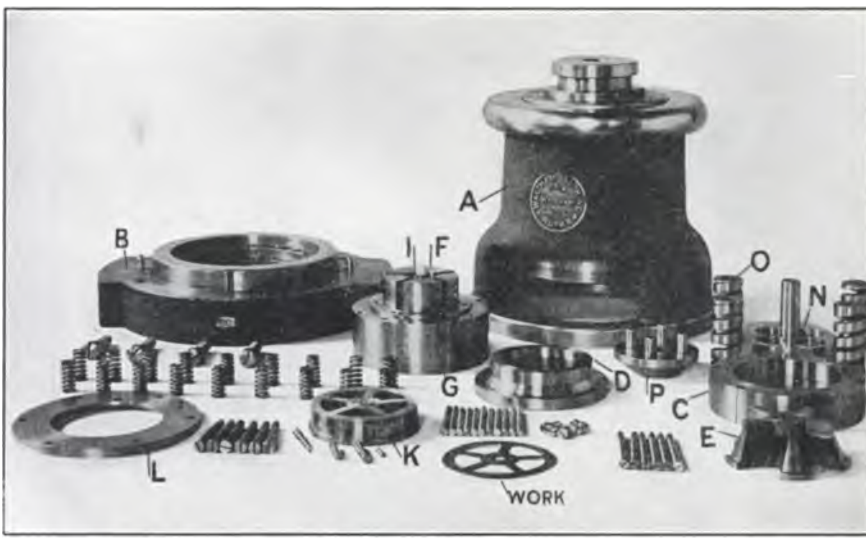


Fig. 477. — Sub press with all details of compound clock wheel die

The stock is stripped from the blanking punch *B* by the spring stripper *K*; this is controlled by coiled springs on fillister head screws *L* which travel in counterbored holes in the press base when the stripper is depressed by the downward stroke of the blanking die. It will be seen that with this combination of spring stripper and knock out which act upon opposite faces of the material and work, the blank will be kept free from distortion.

A Clock Wheel Die for the Sub Press

The half tone, Fig. 477, and the line drawing, Fig. 478, show all details of a compound die for a clock wheel as manufactured in the sub press. This press is also of the arch type and the clock wheel is blanked and pierced to form the central hole and the five openings between the arms, by feeding

the strip of stock through the press between the arched sides of the housing. The wheel produced is 3 in. in diameter.

In referring to the various members of this set of tools the same letters are used on both engravings for purposes of identification. Thus, *A* is the housing which in Fig. 477 is shown removed from the base *B* to allow the punch and die parts to be taken out; *C* is the blanking die for cutting out the wheel, and *D* the blanking punch. The latter fits over the spider shaped piercing die *E* whose five arms define the edges of the triangular openings punched out by piercing punches *F* to form the five arms of the wheel. These piercing punches are built up of five blocks of tool steel finished externally to a taper form of shank to fit into a tapered seat bored and ground in the holder *G*. The holder is also ground externally to a

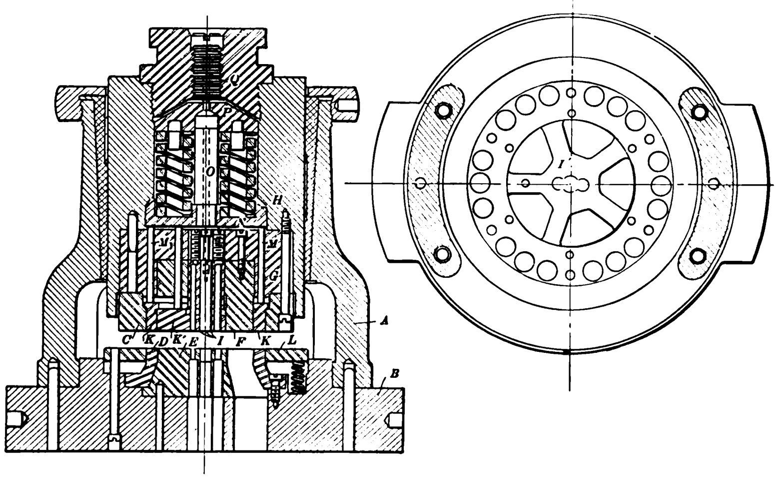


Fig. 478. — Construction of sub press with compound clock wheel dies

slight taper to fit a corresponding taper in the lower end of the plunger *H*. Fillister head screws and dowels are used to secure the piercing punches in their holder and the latter is held by similar devices in the plunger. The holder further carries the small piercing punches *III* (three in number) which are located at the center for piercing the three holes in the blank. The upper dies are provided with the spring actuated knock out ring *K*, *K'*, and the lower tools with the spring controlled stripper *L*. The knock out ring *K* is operated by pins *M* extending upward to thrust plate *N*, and the five armed center of this knock out which is indicated at *K'* is similarly acted upon by other pins abutting against the plate *N* above.

This pressure plate is backed up by four stiff square section coiled springs *O* which are confined in seats between plate *N* and the top plate *P*, the latter being adjusted as required to regulate the spring pressure, by means of the headless screw tapped through the button at *Q*.

The various minor details such as screws, small springs, and dowels are all shown clearly in the two engravings and no special reference to these parts is necessary.

Sub Press Tools for a Clock Frame

Another interesting sub press equipment for making a clock frame is illustrated by Fig. 479. This view shows the work in the foreground, also a smaller piece which is attached to the frame and which is made at the

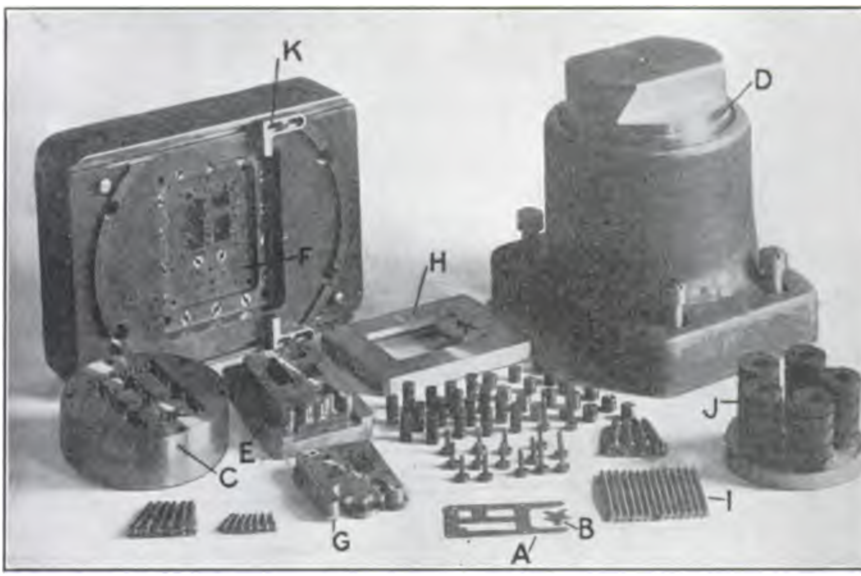


Fig. 479. — Sub press with details of dies for clock frame

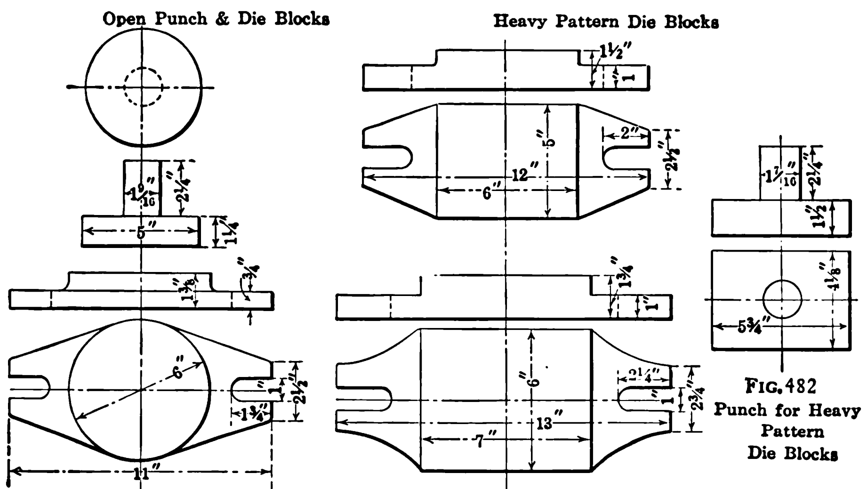
same time, by blanking it from the material between the two projecting arms of the frame.

The frame blanked and pierced is shown at *A* and the smaller piece of work at *B*. The blanking die *C* is made to be attached to the lower end of the plunger *D* and the blanking punch *E* is fitted to the base *F*. The piercing punches are carried by the same holder as the blanking die *C*, and the stripper and knock out for this die and the piercing punches is made as shown at *G*. The stripper for the blanking punch *E* is shown at *H* and the springs and screws for both *G* and *H* are seen at the front and side of these two members. In the same group will be noticed, also, the knock out pins *I* and the pressure springs *J*. The two adjustable stock gages or guides are represented in position at *K*. The manner in which these parts assemble in the plunger and base will be understood from the foregoing and from the sectional views of the other dies which have already been described.

CHAPTER XV

PUNCH AND DIE STANDARDS

The illustrations and tables in this section cover various standards for punch and die parts, die shoes, punch holders, guide pins or pillars, etc. They are all representative of the practice of well-known manufacturers who make extensive use of press tools of different classes and they should therefore be of direct service to many shops and to individual die makers and draftsmen employed where this class of material has not as yet been standardized. Their adoption, in whole or in part, according to require-



Figs. 480–482. — Standard punch and die blocks

ments, will go far toward simplifying the laying out of press tools and their construction in the shop. Furthermore such standards will enable the special work of the pattern shop to be materially reduced.

The drawings and tables are largely self-explanatory and only the briefest reference is necessary in the text.

The sketches, Fig. 480 to 482, show the standard plain open punch holders and die blocks used by one of the principal manufacturers of calculating machines. The majority of press tools in this shop are of the pillar type, and Figs. 483 to 486 inclusive, cover dimensions for the head and base as well as the guide pins or pillars.

The proportions of blanking dies proper, strippers, pressure pads and nests for shaving dies are given in Figs. 487 to 490.

In Figs. 491 to 494 are shown the dimensions of punch holders and die shoes, also the scrap choppers, adopted by a prominent typewriter factory.

The tables and sketches reproduced in Figs. 495 to 499 show details developed from tools used in different shops manufacturing a variety of

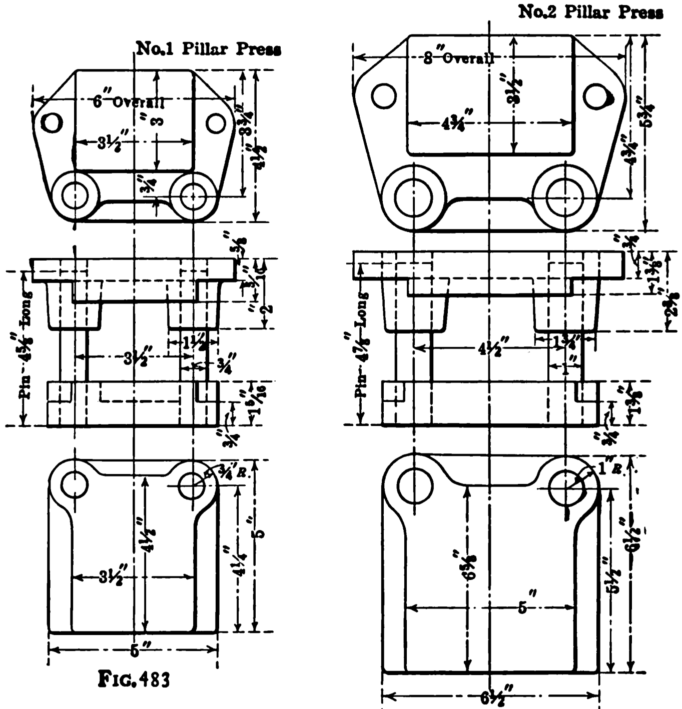


FIG. 483

FIG. 484

FIGS. 483–484. — Standard parts for pillar dies

work, including automobile parts, small electric motors, mailing machine parts, etc. The punch and die holders in Fig. 495 are a development of the four-post type which were often found to cause difficulty through the front pins coming in the way of the operator. In most cases the dies equipped with two guide pins give as satisfactory results as where there are four and the two-post type are considerably easier and more economical to make. The patterns for these holders are so made that they can be used in pairs and the two castings lined up for boring together. The usual practice is to face off both castings, clamp them together in the milling machine and bore both parts to a standard plug gage. Type *A*, Fig. 495, is used for general work and Type *B*, Fig. 496, is adapted especially for round work.

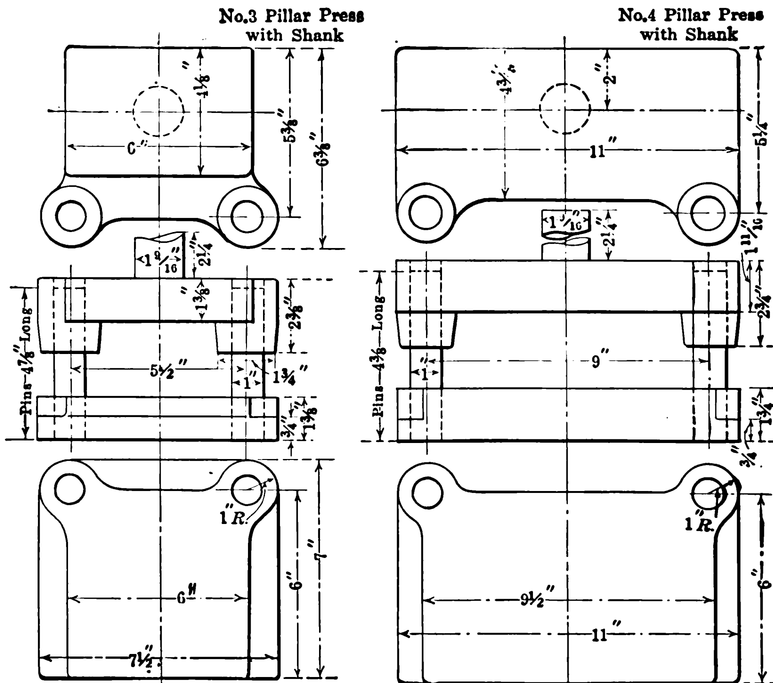
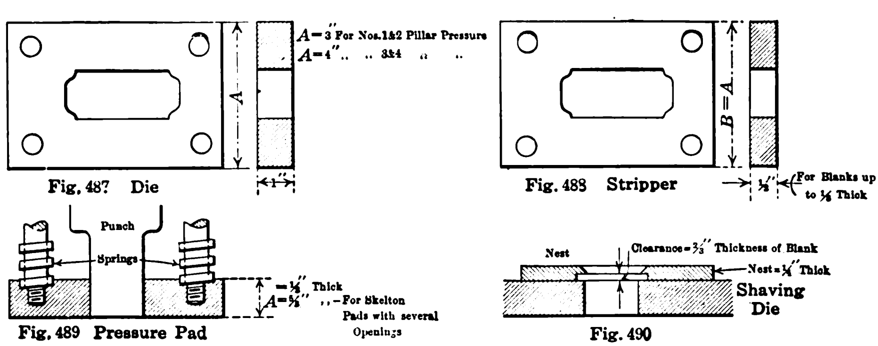


FIG. 485 FIG. 486

FIGS. 485–486. — Standard parts for pillar dies



FIGS. 487–490. — Pressure pad and nest details

STANDARD GUIDE POSTS 1"-ST 13/16" ST 7/8"-ST 13/16" ST

MAKE ONE GUIDE POST 1/16" LARGER THAN THE OTHER

FOR STANDARD GUIDE POSTS SEE INNER MARGIN

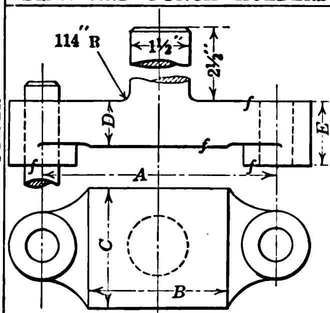


FIG. 491

STANDARD PUNCH HOLDERS	A	B	C	D	E	F	G
	6	3¾	3	1⅛	1¾		
	6	3¾	4	1⅛	1¾		
	7	4	3¼	1⅛	1¾		
	7	4	5	1⅛	1¾		
	8½	5	5	1⅛	1¾		
	8½	6	4	1⅛	1¾		
	9	7	4	1⅛	1¾		
	11	8	4½	1⅛	1¾		
	14	10	4½	1½	2		
	15	12½	3¾	1¾	2¾		
	16⅝	13	4¼	1¾	2¾		

STANDARD DIE SHOES

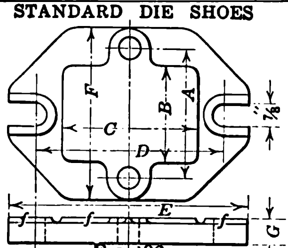


FIG. 492

STANDARD DIE SHOES	A	B	C	D	E	F	G
	6	4¾	5¾	8	10½	7⅝	1¼
	9	7½	5¾	8	10½	10½	1½
	7	6	7¾	9½	12	8⅝	1¼
	6	5	6¼	9½	12	7⅝	1¼
	8½	7	6¾	9½	12	10	1½
	11	9½	6¼	9	11	13	1½

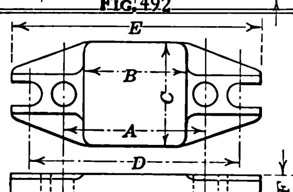


FIG. 493

	A	B	C	D	E	F	G
	6	4	4	8⅞	10⅛	1¼	
	7	5	4	9¾	12	1¼	
	7	5	5	9¾	12	1¼	
	9	7	4½	12¾	15	1¼	
	14	11	5½	17¾	20	2	
	15	13½	4¼	19	21	2¼	
	16⅝	15⅛	7	20	22½	1½	

STANDARD SCRAP CHOPPER

W—Width of Stock
t —Thickness of Stock

Note:- The Die Shoe is Bolted to the Press Bed Thru. Two Holes. These Two Holes are the Distance A (See Charts above) From Center to Center.

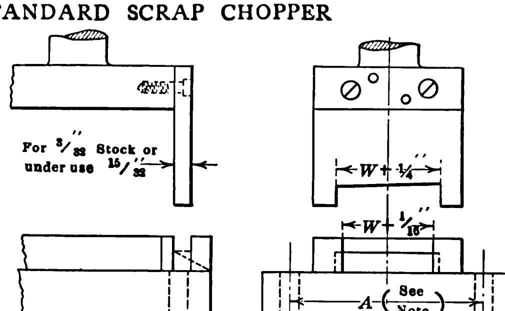
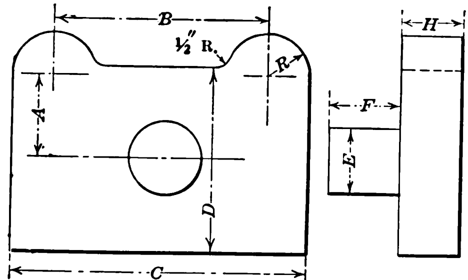


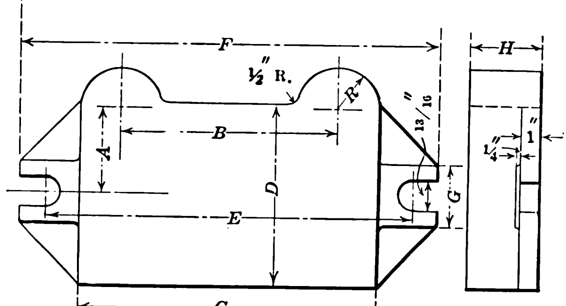
FIG. 494

FIGS. 491–494. — Standard die shoes and punch holders



STANDARD PUNCH HOLDERS (TYPE *A*)
CAST IRON

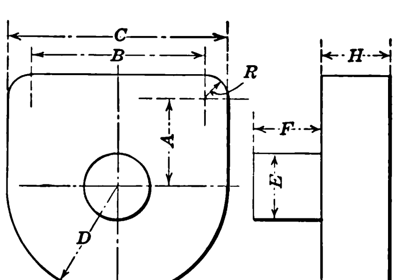
No.	*A*	*B*	*C*	*D*	*E*	*F*	*H*	*R*
1	3	5	8	6	2⅛	2½	2¾	1½
2	3½	6¾	10	7	.⅛	2½	2¾	1⅝
3	4	8¾	12	8	2⅛	2½	2¾	1⅝
4	4½	10½	14	9	2⅛	2½	3	1¾
5	5	12¼	16	10	2⅛	2½	3	1⅞



STANDARD DIE HOLDERS (TYPE *A*)
CAST IRON

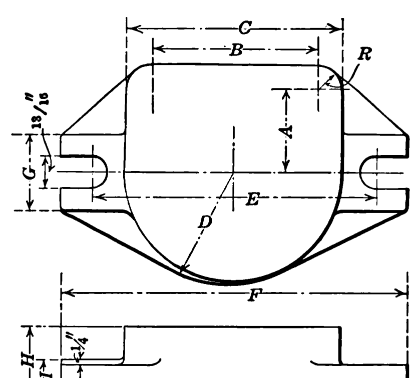
No.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*R*
1	3	5	8	6	10	12	2½	2¾	1½	1½
2	3½	6¾	10	7	12	14	2½	2¾	1½	1⅝
3	4	8¾	12	8	14	16	2½	2¾	1½	1⅝
4	4½	10½	14	9	16	18	2½	3	1½	1¾
5	5	12¼	16	10	18	20	2½	3	1½	1⅞

FIG. 495. — Punch and die standards



STANDARD PUNCH HOLDER (TYPE *B*)
CAST IRON

No.	*A*	*B*	*C*	*D*	*E*	*F*	*H*	*R*
1	2½	5	8	4	2⅛	2½	2¾	1½
2	3⅜	6¾	10	5	2⅛	2½	2¾	1⅝
3	4⅜	8¾	12	6	2⅛	2½	2¾	1⅝
4	5¼	10½	14	7	2⅛	2½	3	1¾
5	6⅛	12¼	16	8	2⅛	2½	3	1⅞



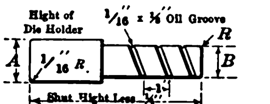
STANDARD DIE HOLDERS (TYPE *B*)
CAST IRON

No.	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*R*
1	2½	5	8	4	10	12	2½	2¾	1½	1½
2	3⅜	6¾	10	5	12	14	2½	2¾	1½	1⅜
3	4⅜	8¾	12	6	14	16	2½	2¾	1½	1⅝
4	5¼	10½	14	7	16	18	2¾	3	1½	1¾
5	6⅛	12¼	16	8	18	20	2¾	3	1½	1⅞

FIG. 496. — Punch and die standards

The guide pins in Fig. 497 are designed for use with blanking and piercing dies and are used in connection with the bushings in Fig. 498. It will be noticed that the pins and bushings are both ground for a press fit in the same size of hole and that the small end of the pin is ground to a sliding fit in the bushing of the corresponding number.

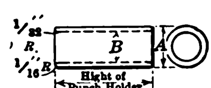
The guide pins in Fig. 499 are intended to be used without bushings and are usually employed in forming dies or in cutting dies where the number of pieces to be produced will not warrant the making of bushings.



Tool Steel Guide Pins Hdn. & Grind

No	A	B	R	Radius of Base
1	1.002	0.999	⅛	1⅛
2	1.127	1.124	⅛	1⅛
3	1.252	1.249	⅛	1⅛
4	1.377	1.373	⅛	1⅛
5	1.502	1.498	⅜	1⅛

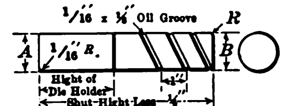
FIG. 497



Guide Pins-Bushings Tool Steel Hdn. & Grind

No	A	B	Radius of Base
1	1.376	1.000	1⅛
2	1.501	1.125	1⅛
3	1.626	1.250	1⅛
4	1.751	1.375	1⅛
5	1.876	1.500	1⅛

FIG. 498



Guide Pins-Tool Steel Hdn. & Grind

No	A	B	R	Radius of Base
1	1.002	0.999	⅛	1⅛
2	1.127	1.124	⅛	1⅛
3	1.252	1.249	⅛	1⅛
4	1.377	1.373	⅛	1⅛
5	1.502	1.498	⅜	1⅛

FIG. 499

FIGS. 497–499. — Standard guide pins and bushings

STANDARDIZING A LINE OF TYPEWRITER TOOLS

The engravings that follow show the standards adopted by a typewriter manufacturer for use in a line of presses made up of Nos. 19, 20 and 73½ Bliss and Nos. 0 and 75-D Stiles machines. In Figs. 500 to 502 are illustrated the standards for the Stiles No. 0 press. The construction drawing, Fig. 500, shows the tools assembled and it will be noticed that guide posts and bushings are used on all of these tools making each outfit practically a pillar sub press.

In Figs. 503 to 506 are shown the equipment for the No. 19 Bliss press. The shoe and punch holder for this press are made in six sizes. The punch holders are shown in Fig. 510 and are the same as those used on the No. 20 press. In Fig. 506 is shown the planing for all the gates for No. 19 presses and also the key for holding the punch holders in the gate.

The standards for the No. 20 press are given in Figs. 507 to 514. There are two combinations of standards for this size of press — one in which the guides are on the center line of the press sidewise, and the other where the guides are placed one in front and the other in the rear of the center line of the press.

As Nos. 19 and 20 presses are most in use here, standard die blanks are carried in stock rough planed, and they are finished planed as required to suit specific conditions. In many cases rectangular blanks are employed, these being screwed into place without the aid of keys. The bolster plate and the standard opening in the bed of the press are shown in Fig. 513.

In Figs. 515 to 520 are illustrated the standard holders for the No.

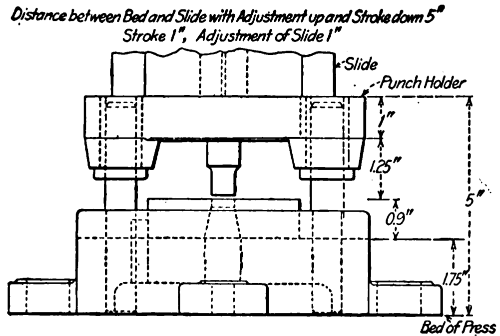


Fig. 500

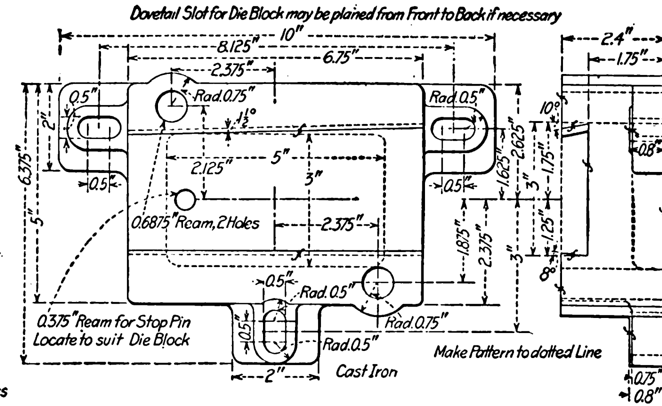
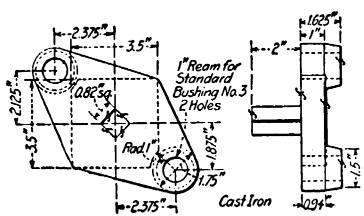
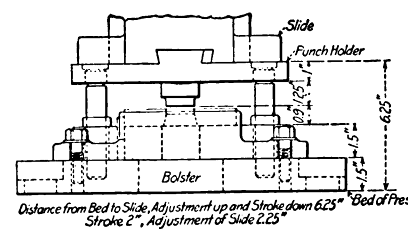
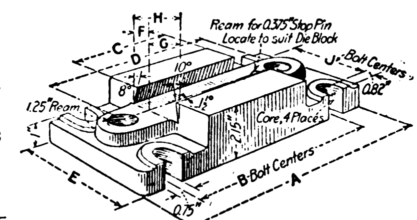


Fig. 501







No.	A	B	C	D	E	F	G	H	J
40	11.5"	8.5"	4"	6.5"	6"	1.25"	1.75"	3"	4.75"
41	11.5"	8.5"	5"	7.5"	6"	1.25"	1.75"	3"	4.75"
42	11.5"	8.5"	6"	8.5"	6"	1.25"	1.75"	3"	4.75"
43	12.5"	9.75"	4.5"	7"	7"	1.75"	2.25"	4"	5.75"
44	12.5"	9.75"	5.5"	8"	7"	1.75"	2.25"	4"	5.75"
45	12.5"	9.75"	6.5"	9"	7"	1.75"	2.25"	4"	5.75"

Fig. 502 Fig. 503 Fig. 504

Figs. 500–504. — Standard dimensions of various press parts

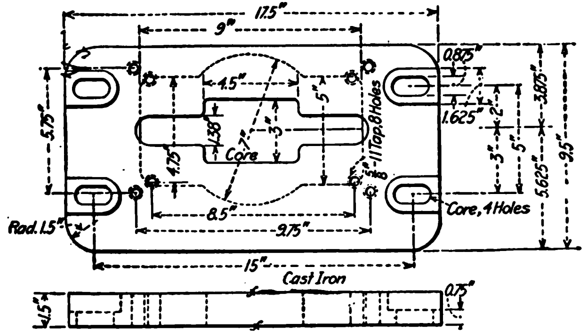


FIG. 505.—Bolster and bed opening

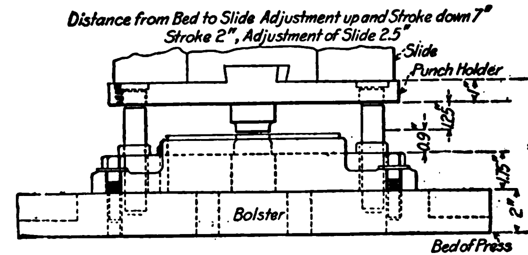


FIG. 507.—Tools for No. 20 Bliss Press

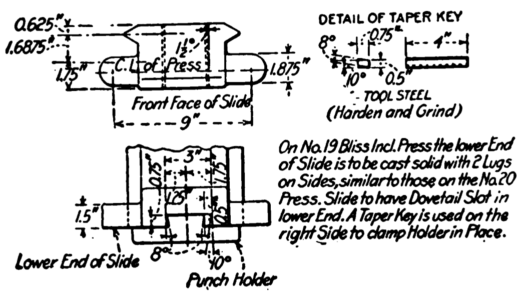


FIG. 506

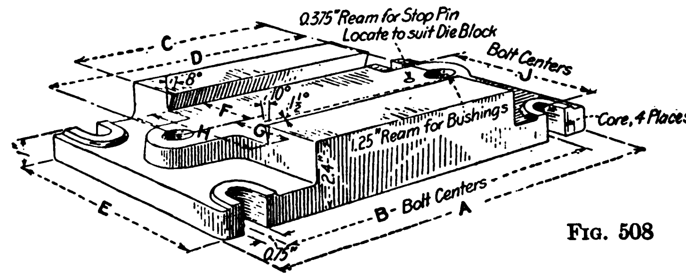
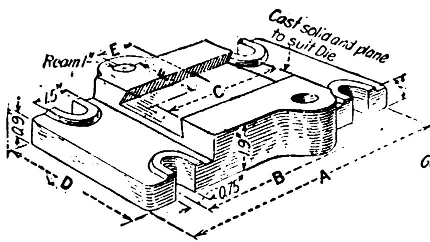


FIG. 508

No.	A	B	C	D	E	F	G	H	J
1	11.5"	8.5"	4"	6.5"	6"	1.25"	1.75"	3"	4.75"
2	11.5"	8.5"	5"	7.5"	6"	1.25"	1.75"	3"	4.75"
3	11.5"	8.5"	6"	8.5"	6"	1.25"	1.75"	3"	4.75"
4	12.5"	9.75"	4.5"	7"	7"	1.75"	1.25"	4"	5.75"
5	12.5"	9.75"	5.5"	8"	7"	1.75"	2.25"	4"	5.75"
6	12.5"	9.75"	6.5"	9"	7"	1.75"	2.25"	4"	5.75"
7	14.5"	11.5"	6"	8.5"	8"	2.25"	2.75"	5"	6.75"
8	14.5"	11.5"	7"	9.5"	8"	2.25"	2.75"	5"	6.75"
9	14.5	11.5"	8.5"	11"	8"	2.25"	2.75"	5"	6.75"

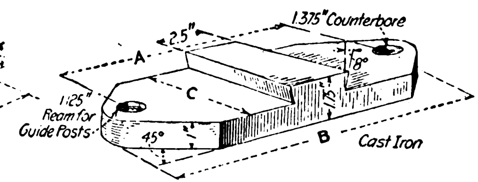
FIGS. 505–508.—Standard punch holders and shoes



No.	A	B	C	D	E	F
50	11.5"	8.5"	6"	6"	1.5"	2.875"
51	12.5"	9.75"	7"	7"	2.125"	2.875"

STANDARD SHOES FOR No. 20 BLISS INCL. PRESS

FIG. 509

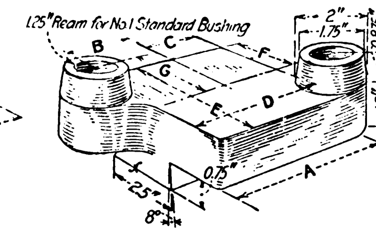


No.	A	B	C
1	6.5"	9"	3.5"
2	7.5"	10"	3.5"
3	8.5"	11"	3.5"
4	7"	9.5"	4.5"
5	8"	10.5"	4.5"

No.	A	B	C
6	9"	11.5"	4.5"
7	8.5"	11"	5.5"
8	9.5"	12"	5.5"
9	11"	13.5"	5.5"

Nos. 1 to 6 inclusive are also used on the No 19 Bliss incl Press

FIG. 510



No.	A	B	C	D	E	F	G
50	5.125"	2.875"	2.25"	4.5"	5"	2.5"	1.5"
51	5.125"	2.875"	2.25"	4.5"	6.25"	3.125"	2.125"

FIG. 511

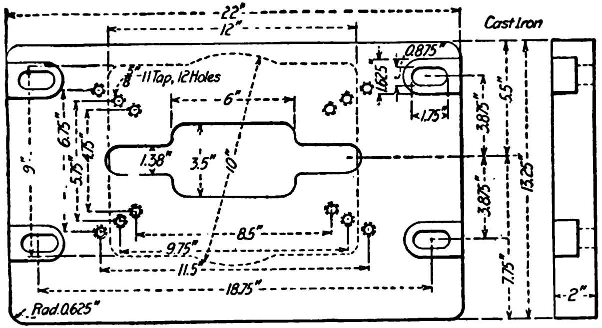


FIG. 513

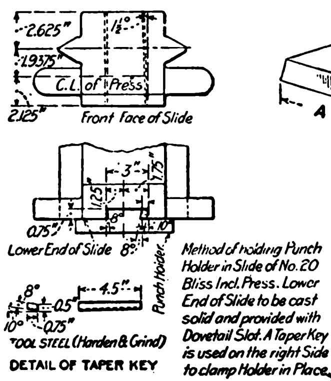
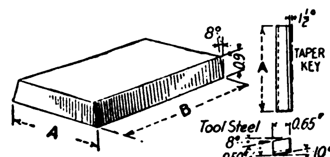


FIG. 514



No.	A	B
1	2.5"	3.5"
2	2.5"	4.5"
3	2.5"	5.5"
4	3.5"	4"
5	3.5"	5"
6	3.5"	6"
7	4.5"	5.5"
8	4.5"	6.5"
9	4.5"	8"

No.	A
1	4"
2	5"
3	6"
4	4.5"
5	5.5"
6	6.5"
7	6"
8	7"
9	8.5"

FIG. 512

FIGS. 512–514. — Standards for No. 20 press

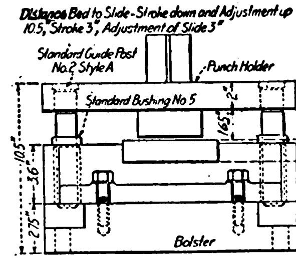


FIG. 515

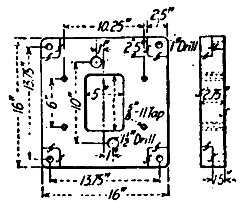
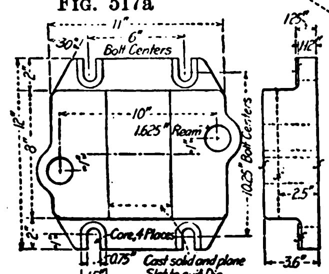


FIG. 517a



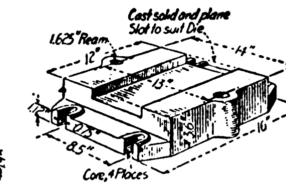


FIG. 516a

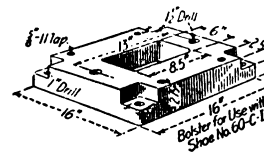


FIG. 516b

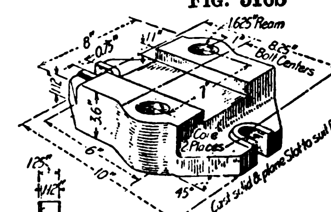


FIG. 518a

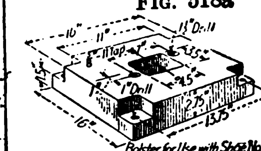


FIG. 518b

FIGS. 515–518. — Standards for No. 79½ press

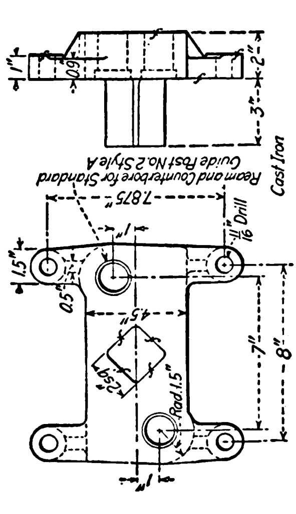


FIG. 519

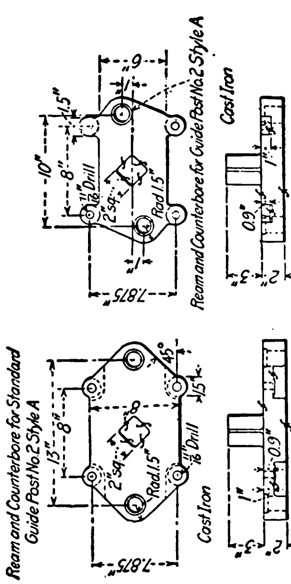


FIG. 520

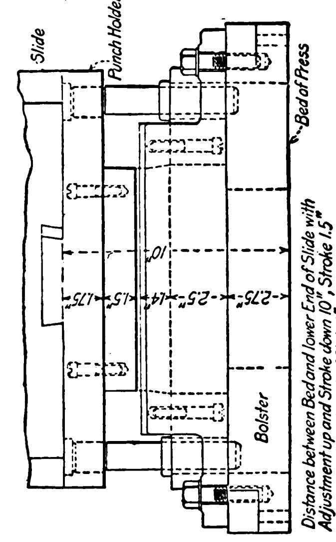
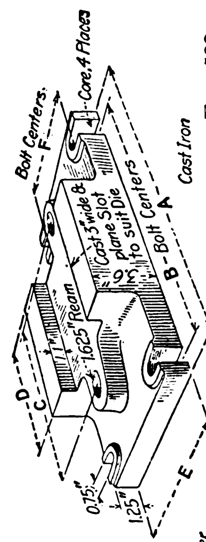


FIG. 521

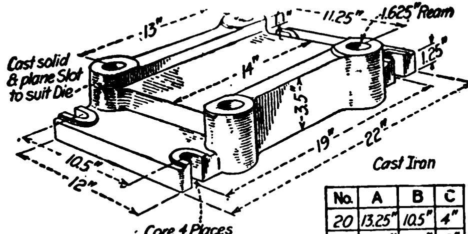


No.	A	B	C	D	E	F
20	16"	13"	10.5"	8"	7"	5.75"
21	16"	13"	10.5"	8"	9"	7.75"
22	16"	13"	12"	10"	7"	5.75"
23	16"	13"	12"	10"	9"	7.75"
24	16"	13"	12"	10"	12"	10.75"
25	20"	17"	14"	12"	7"	5.75"
26	20"	17"	14"	12"	9"	7.75"
27	20"	17"	14"	12"	12"	10.75"
28	20"	17"	16"	14"	7"	5.75"
29	20"	17"	16"	14"	9"	7.75"
30	20"	17"	16"	14"	12"	10.75"

FIG. 522

FIGS. 519–522. — Punch holder, tools and shoes for various presses

FIG. 523



Cast Iron

STANDARD SHOE FOR No. 75 D STILES DOUBLE PITMAN PRESS FOR USE WITH 4 GUIDE POSTS

No.	A	B	C
20	13.25"	10.5"	4"
21	13.25"	10.5"	6"
22	14.75"	12"	4"
23	14.75"	12"	6"
24	14.75"	12"	8"

No.	A	B	C
25	16.75"	14"	4"
26	16.75"	14"	6"
27	16.75"	14"	8"
28	18.75"	16"	4"
29	18.75"	16"	6"
30	18.75"	16"	8"

FIG. 524

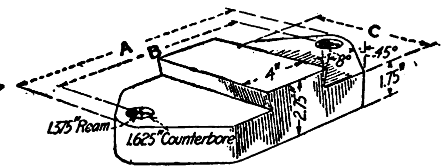
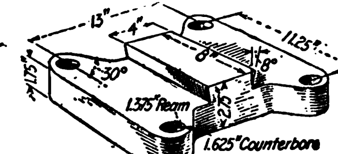


FIG. 525



STANDARD PUNCH HOLDERS FOR No. 75 D STILES DOUBLE PITMAN PRESS

This Style of Bolster is used with Dies having Two Guide Posts. Cast Iron

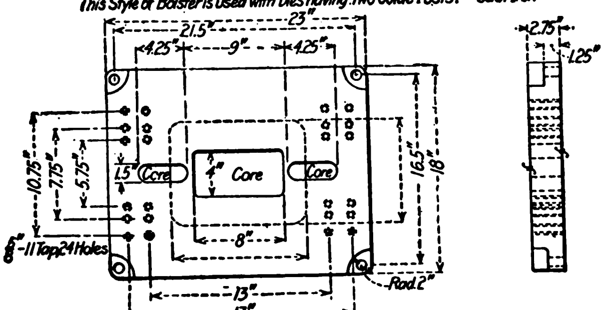
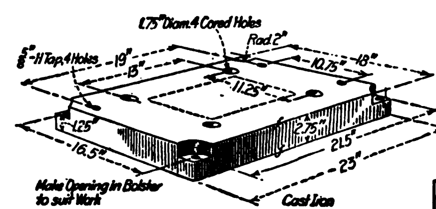
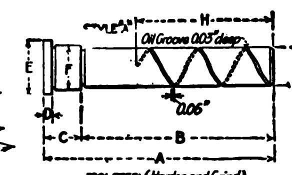


FIG. 526. — Bolster and opening in bed for No. 75-D press





No.	A	B	C	D	E	F	G	H
1	6"	5"	1"	0.25"	1.375"	1.126"	0.9995"	3.5"
2	7.75"	6"	1.75"	0.38"	1.625"	1.376"	1.2435"	4"

FIG. 527. — Special bolster and standard guide

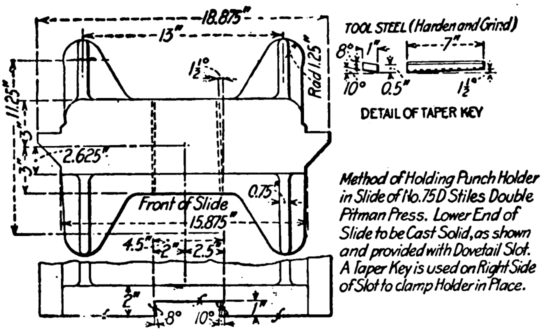
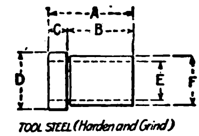


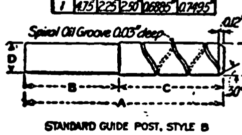
Fig. 528.—Punch holder for No. 75-D press



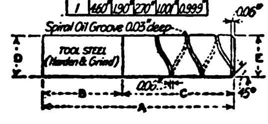
No.	A	B	C	D	E	F
1	2.25"	1.75"	0.5"	1.44"	1"	1.251"
2	3"	2.5"	0.5"	1.75"	1.25"	1.626"
3	1.87"	1.62"	0.25"	1.25"	0.75"	1.001"
4	2"	1.5"	0.5"	1.44"	1"	1.251"
5	4.1"	3.6"	0.5"	1.75"	1.25"	1.626"

Fig. 529.—Special bolster and standard guide

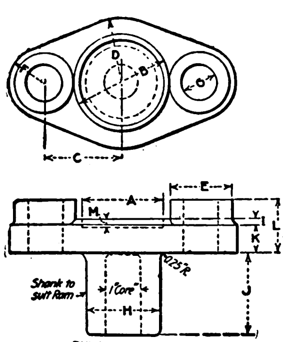
No.	A	B	C	D	E
1	4.75"	2.25"	2.50"	0.6885"	0.7495"



No.	A	B	C	D	E
1	4.60"	1.90"	2.70"	1.001"	0.999"

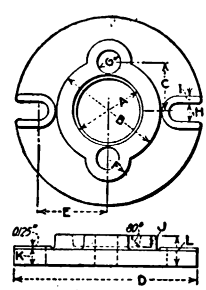


Figs. 530–531.—Standard guide posts



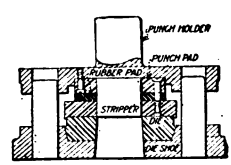
PUNCH HOLDER FOR SIMPLE BLANKING DIES
STEEL CASTING

	2"	3"	4"	5"	6"
A	1.75	2.25	3.25	4	5
B	2.125	2.75	4	5	6
C	1.75	2.125	2.75	3.312	3.812
D	1.25	1.75	2	2.5	3
E	1.25	1.75	1.75	2	2.25
F	0.75	1	1	1.125	1.25
G	0.75	1	1	1.125	1.125
H	1.5	2	2	2	2
I	0.125	0.125	0.125	0.125	0.25
J	1.75	2.25	2.25	2.25	2.25
K	0.625	0.75	0.875	1	1.125
L	1.125	1.375	1.5	1.5	1.75
M	0.125	0.125	0.125	0.25	0.25

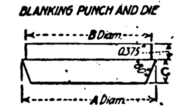


DIE SHOE FOR SIMPLE BLANKING DIE
STEEL CASTING

	2"	3"	4"	5"	6"
A	2	3	4	5	6
B	3	4.5	5.25	6.5	7.75
C	1.75	2.125	2.75	3.312	3.812
D	4.5	8.25	8.25	9.5	11.25
E		3.125	3.375	4	4.75
F	0.875	1	1	1.125	1.125
G	0.75	1	1	1.125	1.125
H		0.812	0.812	0.812	0.812
I		0.312	0.312	0.312	0.312
J	0.5	0.5	0.5	0.625	0.625
K	0.625	0.75	0.875	0.875	1
L	1.25	1.375	1.375	1.375	1.875

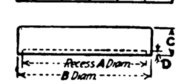


BLANKING PUNCH AND DIE



DIE BED FOR SIMPLE BLANKING DIE
TOOL STEEL

	2"	3"	4"	5"	6"
A	2	3	4	5	6
B	1.812	2.812	3.812	4.812	5.812
C	0.5	0.5	0.5	0.625	0.625



STRIPPER FOR SIMPLE BLANKING DIE
MILD STEEL

	2"	3"	4"	5"	6"
A	1.812	2.812	3.812	4.812	5.812
B	2	3	4	5	6
C	0.625	0.625	0.75	0.75	0.875
D	0.093	0.093	0.093	0.093	0.093

	2"	3"	4"	5"	6"
A	1.75	2.25	3.25	4	5
B	0.5	0.5	0.625	0.625	0.75

PUNCH PAD FOR SIMPLE BLANKING DIE
MILD STEEL

Fig. 532.—Simple blanking punch holder, die shoe and details

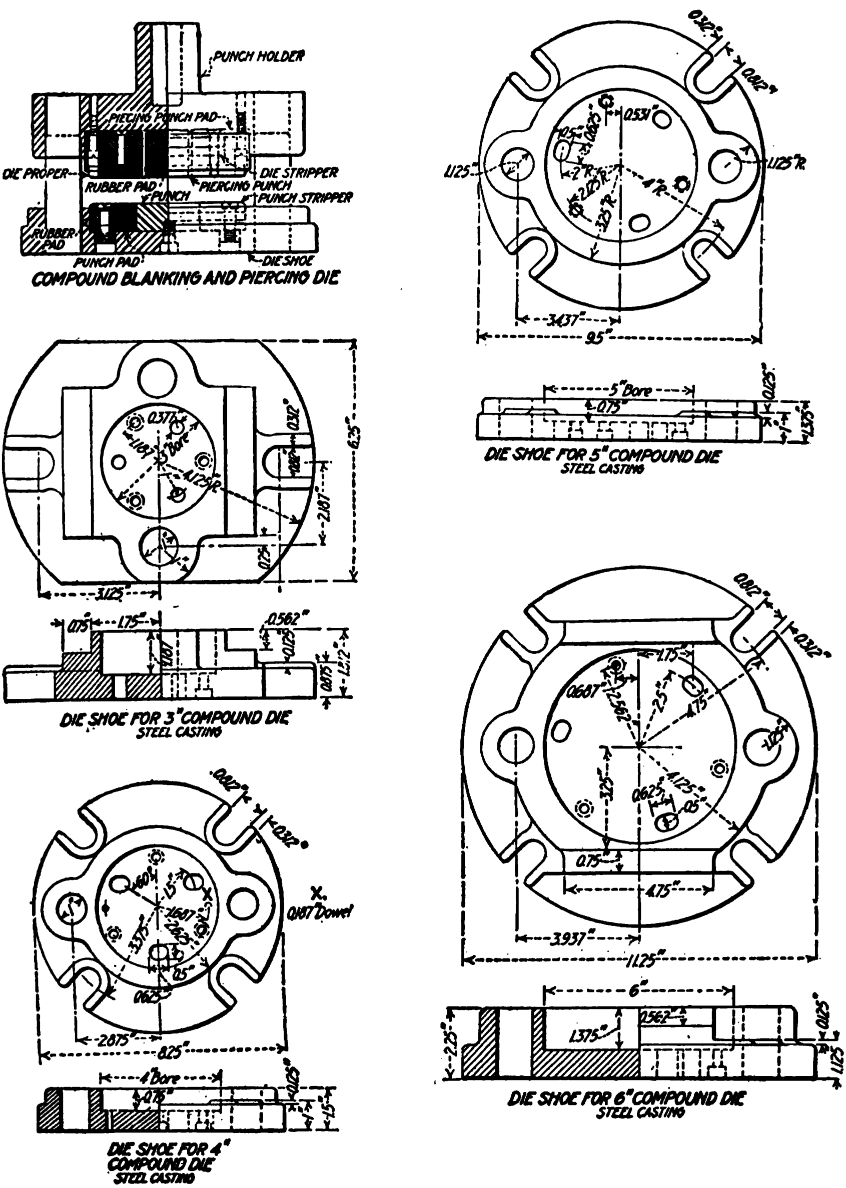


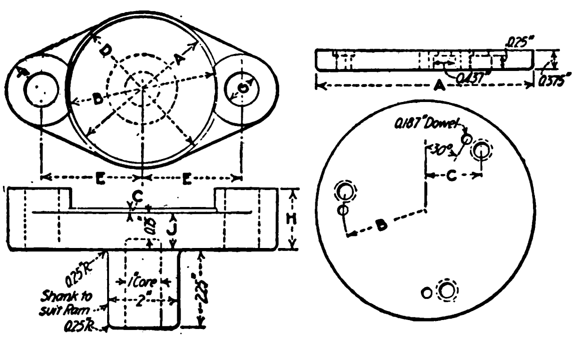
Fig. 533. — Compound die shoes

73½ press. These holders are made in three different styles of one size each to suit varied conditions. In Figs. 521 to 528 are represented the standard punch and die holders for the No. 75-D Stiles double pitman press. These require no description.

The standard guide posts and guide bushings are illustrated in Fig. 529 and two other forms of guide posts are shown in Figs. 530 and 531.

Simple and Compound Die Standards

The following tools, Figs. 532 to 536, were developed in a factory engaged on small press work. The drawings are given in detail and are self-explanatory. The dies in Fig. 532 are of the simple open type; those in



PUNCH HOLDER FOR COMPOUND DIES
STEEL CASTING

	3"	4"	5"	6"
A	3.25	4.25	5.25	6.25
B	3.375	4.5	5.5	6.5
C	0.125	0.125	0.125	0.25
D	3.625	4.5	5.5	6.75
E	2.187	2.875	3.437	3.937
F	1	1	1.125	1.125
G	1	1	1.125	1.125
H	1.5	1.75	2	2.375
J	0.875	1	1.125	1

PUNCH STRIPPER FOR COMPOUND DIE
MILD STEEL

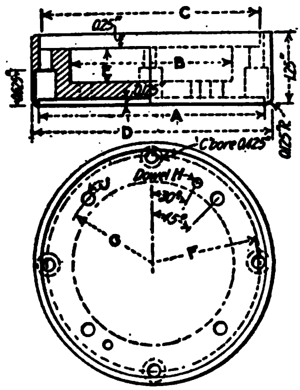
	3"	4"	5"	6"
A	3	4	5	6
B	1	1.5	2	2.5
C	0.812	1.062	1.375	1.75

Fig. 534. — Punch holder and stripper for compound die

the other drawings are of compound tools. All parts are kept in stock and are drilled together for screws and dowels. The shanks and bolt lugs are of course made to suit the press.

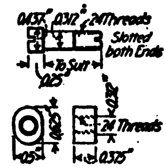
Locations of Holes in Bolsters

It is often noticed in press rooms that bolsters are drilled indiscriminately for screw holes which are located more or less carelessly to suit different dies. To overcome this and other disadvantages the system represented in Fig. 537 has been developed wherein only eight holes are drilled and tapped into the bolster plate.

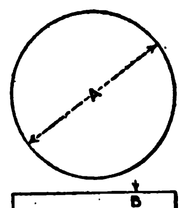


DIE HOLDER FOR COMPOUND DIE
MILD STEEL

	3"	4"	5"	6"
A	3	4	5	6
B	2.25	2.875	3.75	4.75
C	2.875	3.875	4.625	5.625
D	3.25	4.25	5.25	6.25
E	0.687	0.625	0.562	0.562
F	1.437	1.875	2.375	2.875
G	1.25	1.625	2.125	2.625
H	0.125	0.125	0.187	0.187
J	1.B.A.	1.B.A.	0.B.A.	0.B.A.



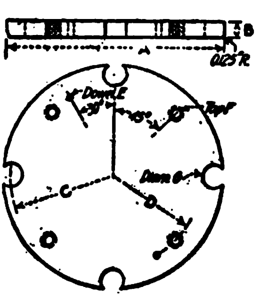
STRIPPER SCREWS FOR COMPOUND DIES



DIE STRIPPER FOR COMPOUND DIES
CAST STEEL, TOUGHENED

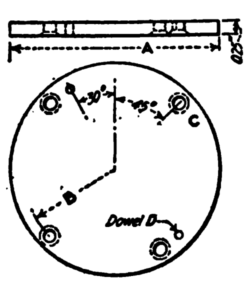
	3"	4"	5"	6"
A	2.25	2.875	3.75	4.75
B	0.312	0.312	0.312	0.375

FIG. 535. — Details of compound die



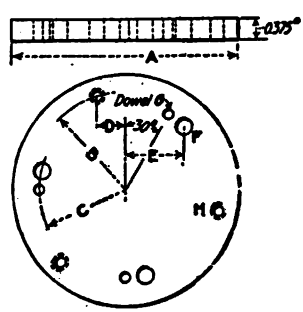
DIE FOR COMPOUND DIES
TOOL STEEL, HARDENED AND GROUND

	3"	4"	5"	6"
A	3	4	5	6
B	0.25	0.312	0.375	0.437
C	1.437	1.875	2.375	2.875
D	1.25	1.625	2.125	2.625
E	0.125	0.125	0.187	0.187
F	1.B.A.	1.B.A.	0.B.A.	0.B.A.
G	0.375	0.425	0.425	0.425



PIERCING PUNCH PAD FOR COMPOUND DIES
MILD STEEL

	3"	4"	5"	6"
A	2.875	3.875	4.625	5.625
B	1.25	1.75	2.125	2.625
C	1.B.A.	0.B.A.	0.B.A.	0.B.A.
D	0.125	0.187	0.187	0.187



PUNCH PAD FOR COMPOUND DIES
MILD STEEL

	3"	4"	5"	6"
A	3	4	5	6
B	1.187	1.687	2.125	2.562
C	1	1.5	2	2.5
D	0.593	0.842	0.531	0.687
E	0.812	1.062	1.375	1.75
F	0.375	0.312	0.312	0.312
G	0.187	0.187	0.187	0.187
H	0.25	0.25	0.312	0.312

FIG. 536. — Compound die details

The tapping is done through the bolster so that no dirt or punchings can lodge at the bottom, but must fall through, thus keeping the holes clear at all times. The die shoe is made of cast iron and has ears at both ends with open elongated slots that have ample clearance, so the bolts enter readily. This also permits adjustment of the die after the shoe containing the die has been placed upon the bolster plate. The holes are so positioned that the shoe may be placed either from front to back or from right to left on the press.

Only two sizes of shoes are in use where this system has been developed. These accommodate 4- and 6-in. width die steel that has been planed in

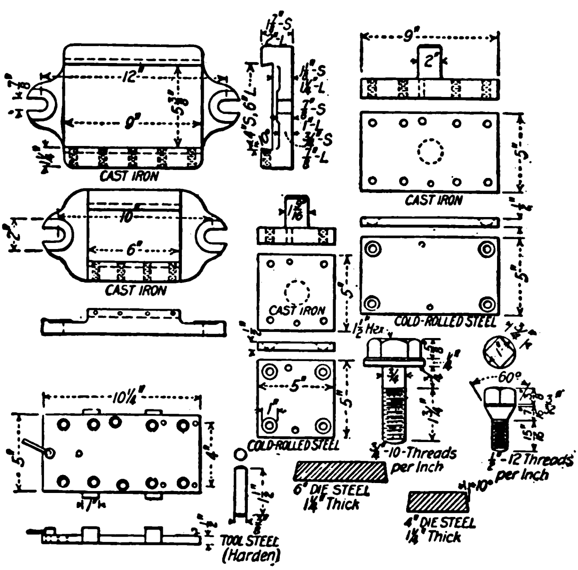


FIG. 537. — Die shoe, punch holder and drill jig

10-ft. lengths with a 10-deg. bevel on each edge and from which pieces are sawed off to the lengths required. These die-steel pieces are held in the die shoe by dog-point tool-steel setscrews that pass through the sides of the die shoe at the same angle as the side edges of the die — 10 degrees. The 4-in. shoe is fastened to the bolster by two $\frac{3}{4}$-in. special-head screws in holes that are tapped 10 in. apart in the bolster, and the 6-in. shoe by screws tapped into holes 12 in. apart.

The punches are mounted in $\frac{1}{2}$-in. thick by 5-in. wide cold-rolled steel plates made in two lengths — 5 in. and 9 in. These cold-rolled steel punch plates are fastened to cast-iron punch holders of the same length by four special taper-headed casehardened screws, as shown in the drawing. Two dowel pins assist these screws to prevent any shifting of the punch plate.

By mounting punches in the cold-rolled steel prior to fastening to the cast-iron punch holder it is evident that not only is it possible to do more accurate work, but also the shank of the holder cannot interfere in the positioning process, as in the old-style methods. With this system only two punch holders are required for each press instead of one for each die in use. The die shoes and punch plates are interchangeable on all presses. A drill jig must be provided, as in the drawing, and it will be observed that there are removable pins and an eccentric clamp with which both sizes of punch plates and punch holder are drilled. The hardened-steel dowel pins shown are a driving fit into the punch holders and remain in them at all times.

It has been learned that this method saves over 20 per cent of the cost of making the punches and dies, and after that the saving in the press room is beyond estimate.

CHAPTER XVI

FINDING THE SIZE OF BLANKS FOR SHELLS AND OTHER DRAWN AND FORMED WORK

In laying out blanking dies for shells and other work the die maker has occasion now and then to do a little figuring to find the area of different forms and to determine the outside dimensions of given areas of circles, ellipses, squares, rectangles, and other shapes. Certain tables included in

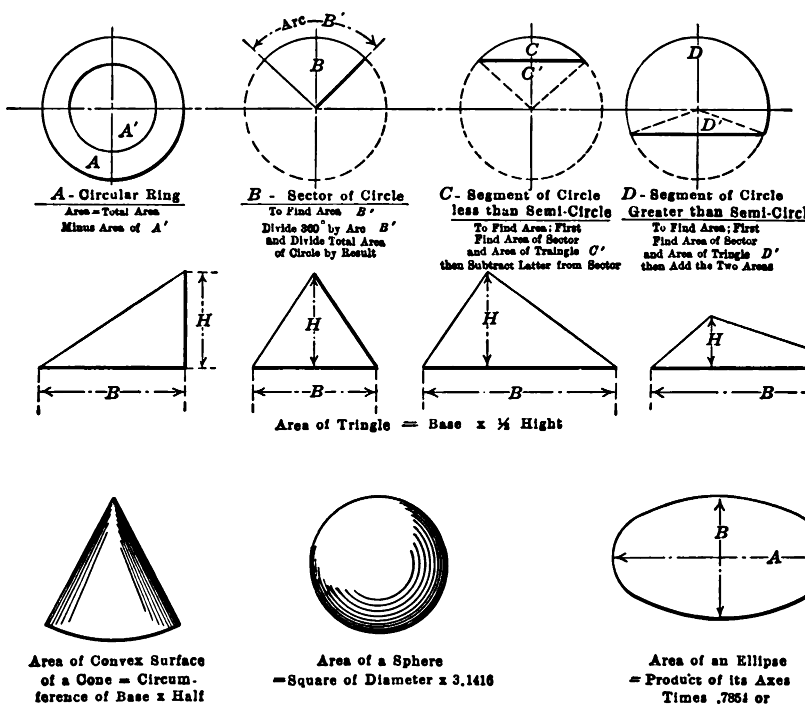
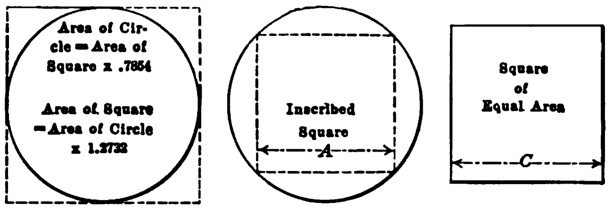


FIG. 538. — Plane surfaces, and cones and spheres

this chapter will be of assistance in the finding of shell blank diameters. Before taking these up for consideration a few facts relative to the computing of areas and dimensions of circles and other regular figures will be referred to.

Table 14, page 370, is a list of simple rules for finding the various dimen-

TABLE 14. RULES FOR FINDING DIMENSIONS OF CIRCLES AND SQUARES



To find	Having given	Rule
Circumference	Diameter	Multiply diam. by 3.1416 or divide diam. by 0.3183.
Circumference	Area	Divide area by 0.07958 and find square root of quotient.
Circumference	Side of an inscribed square (A)	Multiply side (A) by 4.443.
Circumference	Side of square of equal area (C)	Multiply side (C) by 3.545.
Diameter	Circumference	Multiply circumference by 0.3183 or divide circumference by 3.1416.
Diameter	Area	Divide area by 0.7854 and find square root of quotient.
Diameter	Side of an inscribed square (A)	Divide side (A) by 0.7071 or multiply side (A) by 1.4142.
Diameter	Side of square of equal area (C)	Multiply side (C) by 1.1284 or divide side (C) by 0.8862.
Radius	Circumference	Multiply circumference by 0.15915 or divide circumference by 6.28318.
Area	Circumference	Multiply the square of the circumference by 0.07958.
Area	Diameter	Multiply the square of the diameter by 0.7854.
Area	Radius	Multiply the square of the radius by 3.1416.
Area	Circumference and diameter	Multiply the circumference by one-quarter the diameter.
Side of an inscribed square (A)	Diameter	Multiply diameter by 0.7071.
Side of an inscribed square (A)	Circumference	Multiply circumference by 0.2251 or divide circumference by 4.4428.
Side of a square of equal area (C)	Diameter	Multiply diameter by 0.8862 or divide diameter by 1.1284.
Side of a square of equal area (C)	Circumference	Multiply circumference by 0.2821 or divide circumference by 3.545.

sions and the areas of circles and for determining the relations between circles and squares either inscribed or circumscribed. Fig. 538 includes in diagrammatic form, various plane figures, the areas of which the die maker has to compute occasionally, and also covers simple rules for finding the surface areas of cones and spheres. The ellipse, the triangles, and the cone and sphere have often to be worked out for surface areas for work which is to be formed or drawn and it will be found convenient to have the simple rules available for making the necessary calculations. The rules in Table 15 and Fig. 538 are self-explanatory. In the table they are so arranged that with any part given, the required part or dimension can be found at once by following the rule in the third column.

Tables for Shell Blank Diameters

Table 15 has been computed by the E. W. Bliss Company for approximate diameters of blanks for shells from $\frac{1}{4}$ in. diameter by $\frac{1}{2}$ in. high, to 12 in. diameter by 12 in. high. These pages of tables should be found of service for blank calculations. It will be seen from the footnote that shells in the table are figured with sharp corners at the bottom and diameters of shells are taken from the center walls. These blank sizes are approximate only but they will be found a guide for the purpose intended. Necessarily they do not include any allowance for stretch of metal and they are figured without reference to the thickness of the material. The formula used in the computations is given in the footnote and will be found useful in making calculations for other sizes of work not within the range of the tables.

TABLE 15. — APPROXIMATE DIAMETER OF BLANKS FOR SHELLS. (E. W. BLISS CO.)

From 1/4 in. Diameter by 1/2 in. High to 2 7/8 in. Diameter by 3 3/4 in. High

Diameter of shell	Height of shell																				Diameter of shell
	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	
1/4	0.75	0.83	0.90	0.97	1.03	1.09	1.15	1.20	1.25	1.30	1.34	1.39	1.43	1.52	1.59	1.67	1.75	1.82	1.89	1.95	1/4
3/8	0.94	1.04	1.13	1.21	1.28	1.34	1.42	1.48	1.55	1.61	1.67	1.71	1.78	1.88	1.98	2.07	2.16	2.24	2.32	2.40	3/8
1/2	1.12	1.22	1.32	1.41	1.50	1.58	1.66	1.73	1.80	1.87	1.93	2.00	2.07	2.18	2.29	2.39	2.50	2.60	2.69	2.78	1/2
5/8	1.28	1.40	1.50	1.60	1.70	1.79	1.88	1.96	2.04	2.11	2.19	2.26	2.32	2.46	2.58	2.69	2.80	2.92	3.02	3.12	5/8
3/4	1.44	1.56	1.67	1.78	1.89	1.98	2.08	2.16	2.25	2.33	2.41	2.48	2.56	2.70	2.84	2.96	3.09	3.21	3.32	3.43	3/4
7/8	1.59	1.72	1.84	1.95	2.06	2.16	2.26	2.36	2.45	2.54	2.62	2.70	2.78	2.94	3.08	3.22	3.38	3.50	3.63	3.75	7/8
1	1.73	1.87	2.00	2.12	2.23	2.34	2.45	2.55	2.64	2.74	2.82	2.91	3.00	3.16	3.31	3.46	3.61	3.74	3.87	4.00	1
1 1/8	1.87	2.02	2.15	2.28	2.40	2.51	2.62	2.73	2.83	2.93	3.02	3.11	3.21	3.37	3.53	3.69	3.84	3.98	4.12	4.26	1 1/8
1 1/4	2.01	2.16	2.30	2.43	2.56	2.68	2.80	2.90	3.01	3.11	3.22	3.31	3.40	3.58	3.75	3.91	4.07	4.22	4.37	4.51	1 1/4
1 3/8	2.16	2.31	2.45	2.59	2.72	2.84	2.96	3.08	3.18	3.29	3.39	3.49	3.59	3.77	3.95	4.12	4.28	4.44	4.59	4.74	1 3/8
1 1/2	2.29	2.45	2.60	2.74	2.87	3.00	3.12	3.24	3.36	3.46	3.58	3.67	3.77	3.97	4.15	4.33	4.50	4.66	4.82	4.97	1 1/2
1 5/8	2.42	2.59	2.74	2.89	3.02	3.15	3.28	3.40	3.52	3.63	3.74	3.85	3.95	4.15	4.34	4.53	4.70	4.87	5.03	5.20	1 5/8
1 3/4	2.56	2.72	2.88	3.03	3.17	3.30	3.43	3.56	3.68	3.80	3.91	4.03	4.14	4.34	4.54	4.73	4.90	5.08	5.25	5.42	1 3/4
1 7/8	2.70	2.86	3.02	3.18	3.32	3.46	3.59	3.72	3.84	3.97	4.08	4.20	4.30	4.52	4.71	4.91	5.10	5.28	5.45	5.62	1 7/8
2	2.83	3.00	3.16	3.31	3.46	3.61	3.75	3.87	4.00	4.12	4.24	4.36	4.47	4.69	4.90	5.10	5.29	5.48	5.65	5.83	2
2 1/8	2.96	3.13	3.30	3.46	3.61	3.75	3.89	4.02	4.16	4.28	4.40	4.52	4.64	4.86	5.08	5.28	5.48	5.67	5.85	6.03	2 1/8
2 1/4	3.09	3.27	3.44	3.60	3.75	3.90	4.04	4.18	4.31	4.44	4.56	4.68	4.80	5.03	5.25	5.46	5.66	5.86	6.05	6.23	2 1/4
2 3/8	3.22	3.40	3.57	3.74	3.89	4.04	4.18	4.32	4.46	4.59	4.72	4.84	4.96	5.20	5.42	5.64	5.84	6.04	6.24	6.42	2 3/8
2 1/2	3.35	3.54	3.71	3.87	4.03	4.18	4.33	4.47	4.61	4.74	4.87	5.00	5.12	5.36	5.59	5.81	6.02	6.22	6.42	6.61	2 1/2
2 5/8	3.48	3.67	3.84	4.01	4.17	4.32	4.47	4.62	4.76	4.89	5.03	5.15	5.28	5.52	5.76	5.98	6.20	6.40	6.61	6.80	2 5/8
2 3/4	3.61	3.80	3.98	4.15	4.31	4.47	4.62	4.76	4.90	5.04	5.18	5.31	5.44	5.68	5.92	6.15	6.37	6.58	6.79	6.99	2 3/4
2 7/8	3.75	3.93	4.11	4.28	4.45	4.60	4.76	4.91	5.05	5.19	5.33	5.46	5.59	5.84	6.08	6.32	6.54	6.76	6.96	7.17	2 7/8

Approximate blank sizes given above are figured from the formula $D = \sqrt{d^2 + 4\,dh}$; D = diam. of blank; d-diam. of shell; h = height of shell.

NOTE. — Blank sizes given are approximate only; they do not include any allowance for stretch of metal and are figured without reference to thickness of metal. Shells are figured with sharp corners in the bottom. Diameter of shell should be taken from center of thickness of side walls. Sizes of blanks for shells vary according to the varying conditions of die construction — such as fit of die and punch in relation to each other, the size of drawing corner on the die or punch, or amount of pressure on blank-holding surfaces. The character of metal, whether sheet steel, brass, copper, aluminum, nickel, zinc, silver or gold, and its qualities as regards hardness or softness also have a determining influence.

TABLE 15 (*Continued*). — APPROXIMATE DIAMETER OF BLANKS FOR SHELLS

From ¼ in. Diameter by 4 in. High to 2⅞ in. Diameter by 12 in. High

Diameter of shell	Height of shell																					Diameter of shell
	4	4¼	4½	4¾	5	5¼	5½	5¾	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	
¼	2.02	2.08	2.13	2.20	2.25	2.31	2.36	2.41	2.46	2.56	2.66	2.75	2.83	2.93	3.01	3.09	3.17	3.25	3.33	3.40	3.48	¼
⅜	2.48	2.55	2.63	2.70	2.76	2.83	2.90	2.96	3.03	3.15	3.27	3.38	3.48	3.59	3.70	3.80	3.90	3.98	4.08	4.17	4.26	⅜
½	2.88	2.96	3.04	3.12	3.20	3.28	3.35	3.42	3.50	3.64	3.77	3.90	4.03	4.15	4.27	4.39	4.50	4.61	4.71	4.82	4.93	½
⅝	3.23	3.32	3.42	3.50	3.59	3.68	3.76	3.84	3.92	4.08	4.23	4.38	4.52	4.65	4.78	4.91	5.04	5.16	5.28	5.39	5.51	⅝
¾	3.54	3.65	3.75	3.85	3.94	4.03	4.13	4.22	4.30	4.48	4.64	4.80	4.96	5.10	5.25	5.39	5.53	5.66	5.79	5.92	6.05	¾
⅞	3.84	3.95	4.06	4.17	4.27	4.38	4.47	4.57	4.66	4.84	5.03	5.19	5.36	5.52	5.68	5.83	5.98	6.12	6.26	6.40	6.53	⅞
1	4.13	4.24	4.35	4.46	4.58	4.69	4.79	4.89	5.00	5.19	5.39	5.57	5.74	5.92	6.08	6.24	6.40	6.56	6.71	6.86	7.00	1
1⅛	4.39	4.51	4.63	4.75	4.87	4.98	5.10	5.21	5.31	5.52	5.72	5.92	6.10	6.28	6.46	6.63	6.80	6.96	7.12	7.28	7.43	1⅛
1¼	4.65	4.78	4.90	5.03	5.15	5.27	5.39	5.50	5.61	5.84	6.04	6.25	6.45	6.64	6.82	7.00	7.18	7.35	7.52	7.68	7.84	1¼
1⅜	4.88	5.02	5.16	5.29	5.42	5.54	5.67	5.79	5.90	6.13	6.35	6.57	6.78	6.97	7.16	7.35	7.54	7.73	7.89	8.07	8.24	1⅜
1½	5.12	5.26	5.40	5.54	5.68	5.81	5.93	6.07	6.19	6.42	6.65	6.87	7.09	7.30	7.50	7.70	7.89	8.08	8.26	8.44	8.62	1½
1⅝	5.35	5.50	5.64	5.78	5.92	6.06	6.20	6.33	6.45	6.70	6.94	7.17	7.39	7.61	7.82	8.02	8.22	8.42	8.61	8.80	8.98	1⅝
1¾	5.57	5.72	5.88	6.02	6.17	6.31	6.45	6.58	6.71	6.97	7.22	7.46	7.69	7.91	8.13	8.34	8.55	8.75	8.95	9.14	9.33	1¾
1⅞	5.79	5.95	6.10	6.25	6.41	6.55	6.69	6.83	6.96	7.23	7.49	7.73	7.97	8.20	8.43	8.64	8.86	9.07	9.27	9.48	9.67	1⅞
2	6.00	6.16	6.32	6.48	6.63	6.78	6.93	7.07	7.21	7.49	7.75	8.00	8.25	8.48	8.72	8.94	9.17	9.38	9.59	9.80	10.00	2
2⅛	6.21	6.38	6.54	6.70	6.86	7.01	7.16	7.31	7.45	7.73	8.00	8.26	8.52	8.76	9.00	9.23	9.46	9.68	9.90	10.11	10.32	2⅛
2¼	6.41	6.58	6.75	6.91	7.08	7.23	7.39	7.54	7.68	7.97	8.25	8.52	8.78	9.03	9.28	9.52	9.75	9.98	10.21	10.42	10.63	2¼
2⅜	6.61	6.78	6.96	7.13	7.29	7.45	7.61	7.76	7.91	8.21	8.49	8.77	9.03	9.29	9.55	9.79	10.03	10.26	10.49	10.72	10.94	2⅜
2½	6.80	6.98	7.16	7.33	7.50	7.66	7.82	7.98	8.14	8.44	8.73	9.01	9.29	9.55	9.81	10.06	10.31	10.55	10.78	11.01	11.24	2½
2⅝	6.99	7.18	7.36	7.53	7.71	7.88	8.04	8.20	8.36	8.67	8.97	9.25	9.53	9.80	10.07	10.33	10.58	10.82	11.06	11.30	11.53	2⅝
2¾	7.18	7.37	7.55	7.73	7.91	8.08	8.25	8.41	8.58	8.89	9.20	9.49	9.78	10.05	10.32	10.59	10.84	11.09	11.33	11.58	11.81	2¾
2⅞	7.37	7.56	7.75	7.93	8.11	8.29	8.46	8.62	8.79	9.11	9.42	9.72	10.01	10.29	10.57	10.84	11.11	11.35	11.61	11.85	12.09	2⅞

TABLE 15 (*Continued*). — APPROXIMATE DIAMETER OF BLANKS FOR SHELLS

From 3 in. Diameter by 1/2 in. High to 5 7/8 in. Diameter by 3 3/4 in. High

Diameter of shell	Height of shell																				Diameter of shell
	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4	
3	3.87	4.06	4.24	4.42	4.58	4.74	4.90	5.05	5.20	5.34	5.48	5.61	5.74	6.00	6.25	6.48	6.71	6.93	7.14	7.35	3
3 1/8	4.00	4.19	4.38	4.55	4.72	4.88	5.04	5.19	5.34	5.48	5.63	5.76	5.90	6.16	6.40	6.64	6.87	7.10	7.32	7.52	3 1/8
3 1/4	4.13	4.32	4.51	4.68	4.85	5.02	5.18	5.33	5.48	5.63	5.77	5.91	6.05	6.31	6.56	6.80	7.04	7.26	7.48	7.70	3 1/4
3 3/8	4.26	4.45	4.64	4.82	4.99	5.15	5.31	5.47	5.62	5.77	5.92	6.05	6.19	6.47	6.72	6.96	7.20	7.43	7.66	7.87	3 3/8
3 1/2	4.39	4.58	4.77	4.95	5.12	5.29	5.45	5.61	5.77	5.91	6.06	6.20	6.35	6.61	6.87	7.12	7.37	7.60	7.83	8.05	3 1/2
3 5/8	4.51	4.71	4.90	5.08	5.26	5.43	5.59	5.75	5.90	6.06	6.21	6.35	6.49	6.76	7.03	7.28	7.52	7.76	7.99	8.21	3 5/8
3 3/4	4.64	4.84	5.03	5.21	5.39	5.56	5.73	5.89	6.04	6.20	6.35	6.49	6.63	6.91	7.18	7.43	7.68	7.92	8.16	8.38	3 3/4
3 7/8	4.77	4.97	5.16	5.34	5.52	5.69	5.86	6.02	6.18	6.34	6.49	6.64	6.78	7.06	7.33	7.59	7.84	8.08	8.32	8.55	3 7/8
4	4.90	5.10	5.29	5.48	5.66	5.83	6.00	6.16	6.32	6.48	6.63	6.78	6.92	7.21	7.48	7.74	8.00	8.24	8.48	8.71	4
4 1/8	5.02	5.22	5.42	5.61	5.79	5.96	6.13	6.30	6.46	6.62	6.77	6.92	7.07	7.36	7.63	7.89	8.15	8.40	8.64	8.88	4 1/8
4 1/4	5.15	5.35	5.55	5.74	5.92	6.09	6.27	6.43	6.60	6.76	6.91	7.06	7.21	7.50	7.78	8.05	8.31	8.56	8.80	9.04	4 1/4
4 3/8	5.28	5.48	5.68	5.87	6.05	6.23	6.40	6.57	6.73	6.89	7.05	7.21	7.35	7.64	7.93	8.20	8.46	8.71	8.96	9.20	4 3/8
4 1/2	5.40	5.61	5.81	6.00	6.18	6.36	6.53	6.70	6.87	7.03	7.19	7.35	7.50	7.79	8.07	8.35	8.61	8.87	9.12	9.36	4 1/2
4 5/8	5.53	5.74	5.93	6.13	6.31	6.49	6.67	6.84	7.01	7.17	7.33	7.48	7.64	7.93	8.22	8.50	8.76	9.02	9.28	9.52	4 5/8
4 3/4	5.66	5.86	6.06	6.26	6.44	6.62	6.80	6.97	7.14	7.31	7.47	7.62	7.78	8.08	8.37	8.64	8.91	9.18	9.43	9.68	4 3/4
4 7/8	5.78	5.99	6.19	6.39	6.57	6.76	6.93	7.11	7.28	7.44	7.60	7.76	7.92	8.22	8.51	8.79	9.06	9.33	9.59	9.84	4 7/8
5	5.91	6.12	6.32	6.52	6.70	6.89	7.07	7.24	7.41	7.58	7.74	7.90	8.06	8.36	8.66	8.94	9.21	9.48	9.74	10.00	5
5 1/8	6.04	6.25	6.45	6.64	6.83	7.02	7.20	7.37	7.55	7.72	7.88	8.04	8.21	8.51	8.80	9.09	9.37	9.63	9.90	10.15	5 1/8
5 1/4	6.17	6.37	6.58	6.77	6.96	7.15	7.33	7.51	7.68	7.85	8.02	8.18	8.34	8.65	8.94	9.23	9.51	9.78	10.05	10.31	5 1/4
5 3/8	6.29	6.50	6.71	6.90	7.09	7.28	7.46	7.64	7.82	7.99	8.15	8.31	8.48	8.79	9.09	9.38	9.66	9.93	10.20	10.46	5 3/8
5 1/2	6.42	6.63	6.83	7.03	7.22	7.41	7.60	7.77	7.95	8.12	8.29	8.45	8.61	8.93	9.23	9.52	9.81	10.08	10.35	10.62	5 1/2
5 5/8	6.54	6.76	6.96	7.16	7.35	7.54	7.73	7.91	8.08	8.25	8.42	8.59	8.75	9.07	9.37	9.67	9.95	10.23	10.50	10.77	5 5/8
5 3/4	6.67	6.88	7.09	7.29	7.48	7.67	7.86	8.04	8.22	8.39	8.56	8.72	8.89	9.20	9.51	9.81	10.10	10.38	10.65	10.92	5 3/4
5 7/8	6.80	7.01	7.22	7.42	7.61	7.80	7.99	8.17	8.35	8.52	8.69	8.86	9.02	9.34	9.65	9.95	10.24	10.52	10.80	11.07	5 7/8

TABLE 15 (*Continued*). — APPROXIMATE DIAMETER OF BLANKS FOR SHELLS

From 3 in. Diameter by 4 in. High to 5⅞ in. Diameter by 12 in. High

Diameter of shell	Height of shell 4	4¼	4½	4¾	5	5¼	5½	5¾	6	6½	7
3	7.55	7.75	7.94	8.12	8.30	8.48	8.66	8.83	9.00	9.33	9.64
3⅛	7.73	7.93	8.12	8.31	8.50	8.68	8.86	9.03	9.20	9.54	9.86
3¼	7.91	8.11	8.31	8.50	8.69	8.88	9.06	9.23	9.41	9.75	10.08
3⅜	8.08	8.29	8.49	8.69	8.88	9.07	9.25	9.43	9.61	9.96	10.29
3½	8.26	8.47	8.68	8.87	9.06	9.26	9.45	9.63	9.81	10.16	10.50
3⅝	8.43	8.65	8.85	9.06	9.25	9.45	9.64	9.82	10.00	10.36	10.71
3¾	8.60	8.82	9.03	9.23	9.44	9.63	9.82	10.01	10.20	10.56	10.91
3⅞	8.77	8.99	9.20	9.41	9.61	9.82	10.01	10.20	10.39	10.76	11.11
4	8.94	9.16	9.38	9.59	9.79	10.00	10.20	10.39	10.58	10.95	11.31
4⅛	9.11	9.33	9.55	9.76	9.97	10.18	10.38	10.57	10.76	11.14	11.51
4¼	9.27	9.50	9.72	9.94	10.15	10.35	10.56	10.76	10.95	11.33	11.71
4⅜	9.44	9.67	9.89	10.11	10.32	10.53	10.74	10.94	11.14	11.52	11.90
4½	9.60	9.83	10.06	10.28	10.50	10.71	10.92	11.12	11.32	11.71	12.09
4⅝	9.76	10.00	10.22	10.45	10.67	10.88	11.09	11.30	11.50	11.90	12.28
4¾	9.92	10.16	10.39	10.62	10.84	11.05	11.27	11.47	11.68	12.08	12.47
4⅞	10.08	10.32	10.55	10.78	11.01	11.23	11.44	11.65	11.86	12.26	12.65
5	10.24	10.48	10.72	10.95	11.18	11.40	11.61	11.83	12.04	12.45	12.84
5⅛	10.40	10.65	10.88	11.12	11.34	11.57	11.79	12.00	12.21	12.63	13.03
5¼	10.56	10.80	11.04	11.28	11.51	11.74	11.96	12.17	12.39	12.81	13.21
5⅜	10.72	10.96	11.20	11.44	11.68	11.90	12.13	12.35	12.56	12.98	13.39
5½	10.87	11.12	11.36	11.60	11.84	12.07	12.29	12.52	12.73	13.16	13.57
5⅝	11.02	11.28	11.52	11.76	12.00	12.23	12.46	12.69	12.90	13.33	13.75
5¾	11.18	11.43	11.68	11.92	12.16	12.40	12.63	12.85	13.07	13.51	13.93
5⅞	11.33	11.59	11.84	12.08	12.32	12.56	12.79	13.02	13.24	13.68	14.10

Height of shell 7½	8	8½	9	9½	10	10½	11	11½	12	Diameter of shell
9.95	10.25	10.53	10.82	11.09	11.36	11.62	11.87	12.12	12.37	3
10.17	10.48	10.77	11.06	11.34	11.61	11.88	12.13	12.39	12.64	3⅛
10.40	10.70	11.00	11.29	11.58	11.86	12.13	12.39	12.65	12.90	3¼
10.61	10.93	11.23	11.53	11.82	12.10	12.37	12.64	12.91	13.17	3⅜
10.83	11.15	11.46	11.76	12.05	12.34	12.62	12.89	13.16	13.43	3½
11.04	11.36	11.68	11.98	12.28	12.57	12.86	13.14	13.41	13.68	3⅝
11.25	11.58	11.90	12.21	12.51	12.80	13.09	13.37	13.65	13.93	3¾
11.45	11.79	12.11	12.43	12.74	13.04	13.33	13.62	13.90	14.18	3⅞
11.66	12.00	12.33	12.65	12.96	13.26	13.56	13.85	14.14	14.42	4
11.86	12.20	12.54	12.86	13.18	13.49	13.79	14.09	14.38	14.66	4⅛
12.06	12.41	12.75	13.07	13.40	13.72	14.02	14.32	14.61	14.90	4¼
12.26	12.61	12.95	13.29	13.61	13.93	14.24	14.54	14.84	15.13	4⅜
12.45	12.81	13.16	13.50	13.82	14.15	14.45	14.77	15.07	15.37	4½
12.65	13.01	13.36	13.70	14.04	14.36	14.68	14.99	15.30	15.60	4⅝
12.84	13.21	13.56	13.91	14.25	14.57	14.90	15.22	15.52	15.83	4¾
13.03	13.41	13.76	14.11	14.45	14.79	15.11	15.43	15.74	16.05	4⅞
13.23	13.60	13.96	14.32	14.66	15.00	15.33	15.65	15.97	16.28	5
13.41	13.79	14.16	14.52	14.86	15.21	15.54	15.87	16.19	16.50	5⅛
13.60	13.98	14.35	14.71	15.07	15.41	15.75	16.08	16.40	16.72	5¼
13.79	14.17	14.54	14.91	15.27	15.61	15.95	16.29	16.61	16.93	5⅜
13.97	14.36	14.73	15.11	15.47	15.82	16.16	16.50	16.83	17.15	5½
14.15	14.54	14.93	15.30	15.66	16.02	16.36	16.70	17.04	17.36	5⅝
14.33	14.73	15.11	15.49	15.86	16.21	16.57	16.91	17.25	17.58	5¾
14.51	14.91	15.30	15.68	16.05	16.42	16.77	17.11	17.45	17.79	5⅞

TABLE 15 (*Continued*). — APPROXIMATE DIAMETER OF BLANKS FOR SHELLS

From 6 in. Diameter by ½ in High to 12 in. Diameter by 3¾ in. High

Diameter of shell	Height of shell ½	⅝	¾	⅞	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼	2½	2¾	3	3¼	3½	3¾	Diameter of shell
6	6.92	7.14	7.34	7.55	7.74	7.93	8.12	8.30	8.48	8.66	8.83	9.00	9.16	9.48	9.79	10.09	10.39	10.67	10.95	11.22	6
6¼	7.18	7.39	7.60	7.80	8.00	8.19	8.38	8.57	8.75	8.92	9.10	9.27	9.44	9.76	10.07	10.38	10.68	10.96	11.25	11.52	6¼
6½	7.43	7.64	7.85	8.06	8.26	8.45	8.64	8.83	9.01	9.19	9.36	9.54	9.71	10.03	10.35	10.66	10.96	11.25	11.54	11.82	6½
6¾	7.68	7.90	8.11	8.31	8.51	8.71	8.90	9.09	9.27	9.45	9.63	9.80	9.97	10.31	10.63	10.94	11.25	11.54	11.83	12.11	6¾
7	7.93	8.15	8.36	8.57	8.77	8.97	9.16	9.35	9.53	9.72	9.90	10.07	10.24	10.58	10.90	11.22	11.53	11.83	12.12	12.40	7
7¼	8.18	8.40	8.62	8.82	9.03	9.22	9.42	9.61	9.80	9.98	10.16	10.34	10.51	10.85	11.18	11.50	11.81	12.11	12.41	12.70	7¼
7½	8.44	8.66	8.87	9.08	9.28	9.48	9.68	9.87	10.06	10.24	10.42	10.60	10.78	11.12	11.45	11.77	12.09	12.39	12.69	12.99	7½
7¾	8.69	8.91	9.12	9.33	9.54	9.74	9.94	10.13	10.32	10.50	10.69	10.87	11.04	11.39	11.72	12.05	12.37	12.68	12.98	13.27	7¾
8	8.94	9.16	9.38	9.59	9.79	10.00	10.19	10.39	10.58	10.77	10.95	11.13	11.31	11.66	11.99	12.32	12.64	12.96	13.26	13.56	8
8¼	9.19	9.41	9.63	9.84	10.05	10.25	10.45	10.65	10.84	11.03	11.21	11.39	11.57	11.92	12.27	12.60	12.92	13.23	13.54	13.84	8¼
8½	9.44	9.66	9.88	10.10	10.30	10.51	10.71	10.90	11.10	11.29	11.47	11.66	11.84	12.19	12.53	12.87	13.20	13.51	13.82	14.13	8½
8¾	9.69	9.92	10.13	10.35	10.56	10.76	10.96	11.16	11.36	11.55	11.73	11.92	12.10	12.46	12.80	13.14	13.47	13.79	14.10	14.41	8¾
9	9.95	10.17	10.39	10.60	10.81	11.02	11.21	11.42	11.61	11.81	11.99	12.18	12.36	12.72	13.07	13.41	13.74	14.07	14.38	14.69	9
9¼	10.20	10.42	10.64	10.85	11.07	11.27	11.48	11.68	11.87	12.07	12.26	12.44	12.63	12.99	13.34	13.68	14.02	14.34	14.66	14.97	9¼
9½	10.45	10.67	10.89	11.11	11.32	11.53	11.73	11.93	12.13	12.32	12.52	12.70	12.89	13.25	13.61	13.95	14.29	14.61	14.94	15.25	9½
9¾	10.70	10.92	11.14	11.36	11.57	11.78	11.99	12.19	12.39	12.58	12.77	12.96	13.15	13.52	13.87	14.22	14.56	14.89	15.21	15.53	9¾
10	10.95	11.18	11.40	11.61	11.83	12.04	12.24	12.44	12.64	12.84	13.03	13.22	13.41	13.78	14.14	14.49	14.83	15.16	15.49	15.81	10
10¼	11.20	11.43	11.65	11.87	12.08	12.29	12.50	12.70	12.90	13.10	13.29	13.48	13.67	14.04	14.40	14.75	15.10	15.43	15.76	16.08	10¼
10½	11.45	11.68	11.90	12.12	12.33	12.54	12.75	12.96	13.16	13.36	13.55	13.74	13.93	14.30	14.66	15.02	15.36	15.70	16.03	16.36	10½
10¾	11.70	11.93	12.15	12.37	12.59	12.80	13.01	13.21	13.41	13.61	13.81	14.00	14.19	14.56	14.93	15.29	15.63	15.97	16.31	16.63	10¾
11	11.95	12.18	12.40	12.62	12.84	13.05	13.26	13.47	13.67	13.87	14.07	14.26	14.45	14.83	15.19	15.55	15.90	16.24	16.58	16.91	11
11¼	12.20	12.43	12.67	12.91	13.09	13.30	13.52	13.72	13.93	14.13	14.33	14.52	14.71	15.08	15.46	15.82	16.17	16.52	16.84	17.17	11¼
11½	12.45	12.65	12.90	13.11	13.35	13.56	13.77	13.98	14.18	14.38	14.58	14.78	14.97	15.35	15.72	16.08	16.43	16.78	17.11	17.45	11½
11¾	12.66	12.92	13.16	13.39	13.59	13.82	14.03	14.23	14.44	14.63	14.84	15.04	15.22	15.60	15.98	16.34	16.70	17.05	17.39	17.73	11¾
12	12.96	13.20	13.42	13.63	13.86	14.07	14.28	14.49	14.70	14.88	15.10	15.30	15.50	15.88	16.24	16.61	16.96	17.32	17.66	18.00	12

TABLE 15 (*Concluded*). — APPROXIMATE DIAMETER OF BLANKS FOR SHELLS

From 6 in. Diameter by 4 in. High to 12 in. Diameter by 12 in. High

Diameter of shell	Height of shell																					Diameter of shell
	4	4¼	4½	4¾	5	5¼	5½	5¾	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	
6	11.48	11.74	12.00	12.24	12.48	12.72	12.96	13.19	13.41	13.85	14.28	14.69	15.10	15.49	15.87	16.24	16.61	16.97	17.32	17.66	18.00	6
6¼	11.79	12.05	12.31	12.56	12.80	13.05	13.28	13.52	13.74	14.19	14.63	15.05	15.46	15.86	16.25	16.63	17.00	17.36	17.72	18.07	18.41	6¼
6½	12.09	12.36	12.62	12.87	13.12	13.37	13.61	13.85	14.08	14.53	14.97	15.40	15.82	16.22	16.62	17.00	17.38	17.75	18.11	18.47	18.82	6½
6¾	12.39	12.66	12.92	13.18	13.43	13.68	13.93	14.17	14.40	14.86	15.31	15.75	16.17	16.58	16.98	17.38	17.76	18.14	18.50	18.87	19.22	6¾
7	12.68	12.96	13.23	13.49	13.74	14.00	14.24	14.49	14.73	15.19	15.65	16.09	16.52	16.94	17.34	17.74	18.13	18.52	18.89	19.26	19.62	7
7¼	12.98	13.25	13.52	13.79	14.05	14.31	14.56	14.80	15.05	15.52	15.98	16.43	16.86	17.29	17.70	18.11	18.51	18.89	19.27	19.64	20.01	7¼
7½	13.27	13.55	13.82	14.09	14.36	14.62	14.87	15.12	15.37	15.85	16.31	16.77	17.21	17.64	18.06	18.47	18.87	19.26	19.65	20.03	20.40	7½
7¾	13.56	13.84	14.12	14.39	14.66	14.92	15.18	15.43	15.68	16.17	16.64	17.10	17.55	17.98	18.41	18.82	19.23	19.63	20.02	20.40	20.78	7¾
8	13.85	14.14	14.42	14.69	14.96	15.23	15.49	15.74	15.99	16.49	16.97	17.43	17.88	18.33	18.76	19.18	19.59	19.99	20.39	20.78	21.16	8
8¼	14.14	14.43	14.71	14.99	15.26	15.53	15.79	16.05	16.31	16.80	17.29	17.76	18.22	18.66	19.10	19.53	19.95	20.36	20.76	21.15	21.54	8¼
8½	14.43	14.72	15.00	15.28	15.56	15.83	16.10	16.36	16.62	17.12	17.61	18.09	18.55	19.00	19.44	19.88	20.30	20.71	21.11	21.51	21.91	8½
8¾	14.71	15.00	15.29	15.58	15.86	16.13	16.40	16.66	16.92	17.43	17.93	18.41	18.88	19.34	19.78	20.22	20.65	21.07	21.48	21.88	22 28	8¾
9	14.99	15.29	15.58	15.87	16.15	16.43	16.70	16.97	17.23	17.74	18.24	18.73	19.20	19.67	20.12	20.56	21.00	21.42	21.84	22.24	22.64	9
9¼	15.28	15.58	15.87	16.16	16.44	16.72	17.00	17.26	17.53	18.05	18.56	19.05	19.53	20.00	20.45	20.90	21.34	21.77	22.19	22.60	23.00	9¼
9½	15.56	15.86	16.16	16.45	16.74	17.02	17.29	17.57	17.83	18.36	18.87	19.37	19.85	20.32	20.79	21.24	21.68	22.11	22.54	22.96	23.37	9½
9¾	15.84	16.14	16.44	16.74	17.03	17.31	17.59	17.86	18.14	18.66	19.18	19.68	20.17	20.65	21.12	21.57	22.02	22.46	22.89	23.31	23.72	9¾
10	16.12	16.43	16.73	17.02	17.31	17.60	17.88	18.16	18.43	18.97	19.49	20.00	20.49	20.97	21.44	21.90	22.36	22.80	23.24	23.66	24.08	10
10¼	16.40	16.71	17.01	17.31	17.60	17.89	18.18	18.46	18.73	19.27	19.80	20.31	20.81	21.29	21.77	22.23	22.69	23.14	23.58	24.01	24.43	10¼
10½	16.68	16.99	17.29	17.59	17.89	18.18	18.47	18.75	19.03	19.57	20.10	20.62	21.12	21.61	22.09	22.56	23.02	23.47	23.92	24.35	24.78	10½
10¾	16.95	17.27	17.58	17.88	18.18	18.47	18–76	19.04	19.32	19.87	20.40	20.93	21.43	21.93	22.41	22.89	23.35	23.81	24.25	24.69	25.13	10¾
11	17.23	17.55	17.86	18.16	18.46	18.76	19.05	19.33	19.62	20.17	20.71	21.23	21.74	22.24	22.73	23.21	23.68	24.14	24.59	25.04	25.47	11
11¼	17.50	17.81	18.12	18.44	18.74	19.03	19.33	19.62	19.90	20.46	21.01	21.54	22.05	22.55	23.06	23.54	24.00	24.47	24.92	25.37	25.82	11¼
11½	17.78	18.09	18.41	18.71	19.02	19.32	19.63	19.92	20.20	20.76	21.30	21.84	22.36	22.87	23.36	23.85	24.33	24.80	25.25	25.70	26.15	11½
11¾	18.05	18.38	18.70	19.01	19.32	19.61	19.90	20.21	20.50	21.05	21.61	22.14	22.67	23.18	23.68	24.17	24.66	25.13	25.58	26.04	26.49	11¾
12	18.33	18.64	18.97	19.28	19.59	19.89	20.20	20.49	20.77	21.35	21.90	22.45	22.97	23.50	23.99	24.48	24.97	25.45	25.93	26.37	26.84	12

In making different calculations for blanks of various dimensions, complete tables of circles with areas, and circumference are extremely useful, and indispensable data of this kind with other tables on stock thicknesses by gages, weights, etc., will be found in the *American Machinist's Handbook* worked out to the smallest detail for convenience of reference. It is taken for granted that the above book is already in the hands of the reader of this volume and it is therefore unnecessary to reproduce in this treatise the tables referred to which with other valuable reference matter pertaining to the subject runs to many pages in extent. A table of stock thicknesses by the most commonly used gages is, however, given in this book on page 35, Chapter II.

Laying Out a Blank for a Rectangular Drawn Shell

To eliminate some of the trial blanks in making dies for drawing rectangular boxes the following method is suggested:

Let us assume that the box at *C*, Fig. 539, is required and we wish to determine the size and shape of the blank. We draw the center lines *B*,

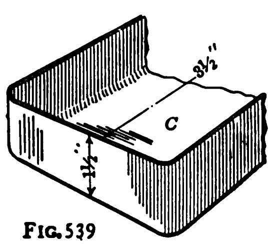


FIG. 539

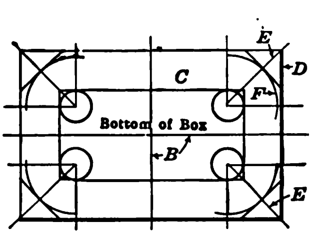


FIG. 540

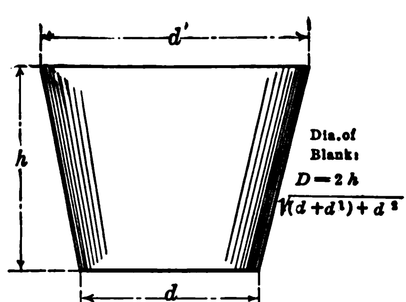


FIG. 541

FIGS. 539–541

Fig. 540, after which the bottom of the box is laid out as at *C*; then lay out the outer box *D*, the distance from *C* to *D* being slightly less than the 1½ in. specified, say $1\frac{15}{32}$ in. Draw line *E* through the corners of *C* and *D* and scribe the required radius of one inch.

In the *American Machinist Handbook* we find that for a shell 1 in. in diameter and 1½ in. high the blank diameter given is 2.65 in., which is obtained from the formula

$$D = \sqrt{d(d + 4h)}$$

where

D = Blank diameter,
d = Diameter of finished shell,
h = Height of finished shell,

or it may be expressed as follows: Add diameter of finished shell to four times its height; multiply this result by the diameter of the finished shell and extract the square root of the product; this root will be the required blank diameter.

With a radius equal to one-half this amount scribe an arc at each corner as at F, and connect this arc to the outer lines D by curved lines, as shown, the radius of which can be made several times larger than the corner radius of finished shell.

After this is done we have a real trial blank, a duplicate of which should be made in case alterations are necessary.

Blanks for Tapered Shells

From the same source referred to above, we have the formula for a tapered shell blank as follows: Fig. 541 shows a taper shell with small diameter of finished shell represented at d, large diameter at d' and blank diameter D, and height h. The formula is then $D = 2\,h\sqrt{(d + d') + d^2}$.

CHAPTER XVII

LAYING OUT AND MAKING TEMPLETS AND DIES

There are various methods of laying out dies and boring and machining to correct outline. The method selected will vary with the experience of the die maker, the equipment of the tool room where he is employed, the class of work for which the die is to be used, and the corresponding degree of accuracy to which the die must be held in its production.

The methods of one shop may seem crude when compared with the practice elsewhere; on the other hand, the methods of the more exacting tool room may seem unnecessarily refined to those employed in the former shop. Both grades of workmanship are undoubtedly justified in the results demanded of the two distinct classes of shops, and the products of two press rooms are legitimately of different grades of accuracy, just as the work produced in the milling, turning and other machine departments of different plants may justifiably vary in respect to the limits adhered to in accordance with the general character of the article manufactured.

Quality and quantity of output are naturally the two important factors in determining the degree of nicety to which a set of press tools should be held. The same factors are the determining ones in fixing the type and design of the tools as well. Without accurate dies, accurate press work need not be expected, and with tools of improper design and construction satisfactory results in the direction of high production and low cost of upkeep are out of the question.

A great deal of judgment is often necessary to fix the standard to which a set of tools should be held. A small lot of punched parts may be as exacting in the limits of accuracy demanded as a run of work involving a million pieces. Yet where the latter case would justify the expenditure of any necessary amount of time and care in the production of the tools, the same expense for the dies for a small total output might mean nothing better than a very heavy loss on the part of the tool room. Such a condition might suggest the application of some other means altogether for the handling of the work, thus eliminating the making of the press tools entirely for this particular article.

While there are certain classes of expensive machines made up very largely of press made members where the requirements throughout are universally conceded to be exacting and where only the closest workman-

ship upon the part of the die makers is passed by the inspectors, it is not the case on the other hand that all cheaply marketed apparatus is necessarily produced by cheap tools, of indifferent degree of accuracy. For there are instances where accuracy of parts is not demanded by the character of the completed article itself, but rather by its very cheapness which necessitates a quality of exactness which will insure all of its parts admitting of assembling with absolutely no delay upon the part of the bench hands, for a few moments of lost time at this point may more than eliminate the narrow margin between total cost of production and the marketable figure to which the completed piece must be held.

These conditions have more than a little to do with the grading of work qualities in the tool room. The experienced die maker will adapt his methods, so far as his equipment permits, to the requirements of each particular set of dies, if he is desirous of seeing the tools progress with the greatest degree of despatch commensurate with the special necessities of each job as it comes to his bench. And this does not mean that he will necessarily turn out at any time what might be called a "sloppy" set of dies, but rather that he will always make the very best tools required for any given grade of work and vary his methods and degrees of refinements to harmonize with the results he wishes to attain.

The process of locating and boring holes in dies and punch plates has been developed along parallel lines to the similar operations involved in the production of high-grade jig work. The use of the vernier height gage in laying off work centers and outlines, the application of the well-known button and master plate methods, the use of verniers and micrometer heads on milling machines and various systems of end and distance gages have all been found of great value in the construction of press tools. There are innumerable instances where such applications as these are as readily made to die work as to the more commonly known classes of jig work where some one or other of the above methods is so frequently resorted to for the locating of hole centers at exact distances. Then, too, the universal dividing head for the miller has its every day uses on punch and die operations just as it has long been applied to the numerous problems arising in connection with precision tool work in general. An intimate knowledge of the possibilities of the dividing head including the additional flexibility of this device which has been brought about by the extension of differential indexing, is becoming an almost indispensable part of the die makers personal equipment.

There are various special machines, as well as attachments for standard tools, that have been developed for die making as also for general precision tool work. In several instances such equipment has been originated specifically for facilitating the production of dies alone, although like many other lines of tools this equipment has gradually been expanded in its

usefulness and it now covers the necessities of other classes of work as well. Certain types of milling machines, slotters and shapers, slotting attachments, filing machines and so on are cases in point. The precision drilling machine has been found as invaluable for die operations as for jig plate drilling and boring, and the bench lathe with its milling attachment, traverse spindle grinder and other appurtenances, has for long been one of the tools that the die maker cannot dispense with.

It is the purpose of this section to show some of the applications of the foregoing principles and tools to the solution of various interesting problems of the die maker.

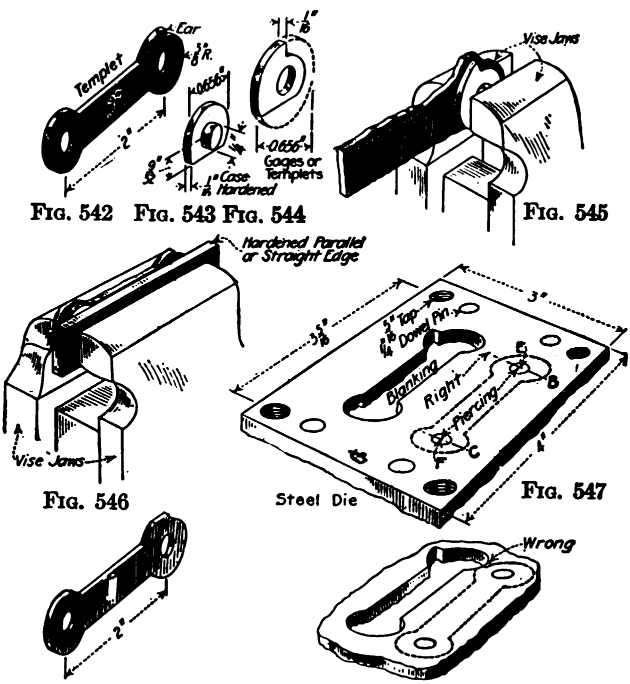


FIG. 542 FIG. 543 FIG. 544 FIG. 545 FIG. 546 FIG. 547 FIG. 548 FIG. 549

FIGS. 542–549. — Simple dies and templets

MAKING AND USING SIMPLE TEMPLETS

An easy and simple way of making templets for use in connection with die work is illustrated by the following engravings:

The dies referred to are of the simple piercing and blanking type commonly known as follow dies, which are to produce blanks similar to the templet shown in Fig. 542. For this piece any dimension can vary 0.004 or 0.005 in.

Several blanks $\frac{1}{16}$ in. thick are wanted for experimental purposes, one to be used as a templet. About the best way to make the first lot by hand

is to cut several pieces of material to the proper length and width and clamp them together. Lay off the $\frac{1}{4}$-in. holes 2 in. apart and drill and ream them. Large holes should not be drilled in *single* thin pieces when a *round* hole is required.

The next step is to make the gages shown in Figs. 543 and 544. The gage shown in Fig. 543 is for the $\frac{3}{8}$-in. radius at the ends, and the flat shown on one side is for establishing a line $\frac{9}{32}$ in. each side of the center, which is half the width of the straight part of the link. The gage shown in Fig. 544 is a $\frac{15}{16}$-in. washer $\frac{1}{16}$ in. thick with a $\frac{1}{4}$-in. hole that fits over the stem of the templet, Fig. 543, which should be $\frac{7}{64}$ in. long. It requires only a few minutes to make these pieces and saves a lot of bother later. They should be casehardened in cyanide and used as templets in filing the ends of the work shown in Fig. 542.

In Figs. 545 and 546 is shown the proper way of holding the work to be filed. This finishes the model, and if we have worked with reasonable care up to this point we are ready for the die.

After the steel die block has been surfaced and squared, the face should be treated by heating until a dark-blue color is obtained, or by rubbing with a little clean waste dampened with sulphate of copper solution. Another good surface for a layout is obtained by filing or grinding off all tool marks and rubbing with emery cloth. The rubbing should not be done straight across, but around and around, covering only a small portion at a time. Layout lines are easily seen upon this dull finish.

In Fig. 347 is shown the proper layout for this die.

With a very fine scriber draw the lines *B* and *C*, 2 in. apart, crosswise of the steel 1 in. from the center, and a line lengthwise about $\frac{1}{4}$ in. from the center. With the dividers set to $\frac{29}{32}$ in., which is the width of the templet at the large end plus $\frac{1}{16}$ in., which we allow for scrap, lay off *E* and *F*, using as centers the intersection of *B* and *C* with the lengthwise line. The layout should always be reckoned from the large end of the blank. Fig. 548 shows a blank with a clipped ear, the result of the layout shown in Fig. 549.

We could bore this die on the miller without a layout, but we would have to put the clearance in later, so it is best to do it in the lathe, using the compound rest set for $\frac{3}{4}$-degree clearance for the $\frac{3}{4}$-in. holes, and taper-ream the $\frac{1}{4}$-in. holes. The straight part in the middle can be drilled out and finished in the miller or shaper with an extension tool, and the $\frac{15}{32}$-in. radius also. When the screw holes are drilled and tapped and the dowel pin-holes drilled, the die is ready for hardening, after which it is ground on both sides and fitted to the shoe.

A templet should be marked "Die" on one side and "Punch" on the other, as an irregular punch will not fit the die if laid out from the same side of the templet. In laying out the die the surface marked "Die" should lie next to the steel, using the other side for the punch. As there are

several styles of die shoes and punches, the workman should be governed largely by the material furnished. The piercing punch holes in the punch holder are located by drilling through the die from the back, with the blanking punch in place. The most important thing in a follow die is to place the piercing holes in proper relation to the blanking. Then the die becomes a master by which to make and align the punches.

The dotted outline of the blank on Fig. 547 is for the purpose of showing the proper layout.

Some Templet Tools

In Fig. 550 some handy appliances are shown for use in connection with the making and application of templets for dies. In the foreground of this photographic view is a scriber *A* that is a most useful tool for marking with very fine line around the edge of a templet. The handle is $\frac{1}{8}$ in.

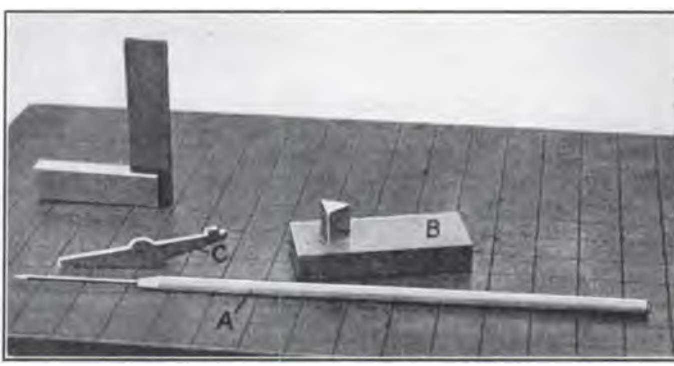


Fig. 550. — Templet tools

diameter drill rod with a point inset of $\frac{1}{32}$ in. diameter wire ground to a sharp point that enables lines to be scribed at all points along a templet edge and even in very small corners where the radius is so slight as to make it impossible to follow with anything much coarser than a needle point.

The tool *B*, with the short vertical post that gives it a resemblance to a die square, is for finishing the edges of templets like the one, say, at *C*. The base or block is about $2\frac{1}{2}$ in. long by $\frac{1}{4}$ in. thick. It is fitted with a three cornered post as shown which is made of tool steel and hardened and ground to sharp edges on all three corners. This tool is used as a scraper for removing the slight burr on the edge of the templet and for finishing the edge perfectly square with the flat faces. The tool is held with the templet face resting against the upper face of the block, and when the tool is moved carefully along the edge of the templet it necessarily brings the edge true and square with the templet face.

Laying Out and Roughing Out Dies

The work illustrated in Figs. 542 to 549 covered the working out of a die from a templet where the main portion of the die admitted of working out by simple drilling of the stock and finishing out on the miller or shaper. This slot could in fact have been milled from the enlarged holes already bored at the ends, without preliminary rough drilling if so desired, the process selected depending upon the relative amount of time required by the alternative methods. There are many cases though, where the complete die contour must be outlined and blocked out by rough drilling and the various tools for facilitating this operation are of interest at this point.

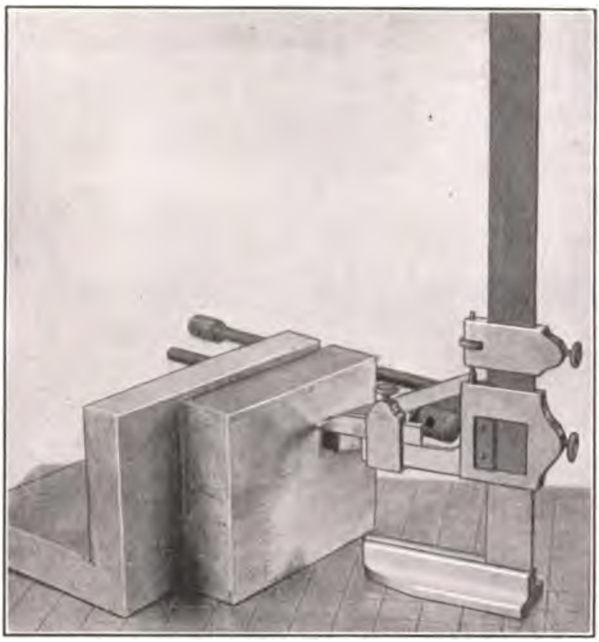


Fig. 551. — Vernier height gage used in laying out dies

The die opening may be laid out by a templet as before, or the various working points, center lines, centers of radii, etc., may be laid off on the die block by setting up on an angle plate as in Fig. 551 and applying the vernier height gage as illustrated. With the die block planed square on ends and edges and using a true surface plate as shown, the working lines and centers desired may be laid off accurately and very conveniently.

If, then, the die opening is to be drilled for finishing by shaping, milling, and filing, the simple tools shown below will be found of value in locating the series of hole centers so that the drill will do most of the work, leaving

but little stock between for removal afterward. There are different types of center punches for this class of work. Some die makers use what is known as the spacing center punch, others prefer the type of punch which strikes the center for the drill and at the same time forms a circle by which the punch is set for the next center and so on. This punch undoubtedly simplifies the whole process very appreciably.

Application of the Spacing Center Punch

If the spacing center punch is to be used the solid type shown in Fig 552 has few equals. A set of four such punches with the punch points $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{3}{8}$ in. apart will cover all requirements for general die work. A set of these punches can be made by any toolmaker in a short time.

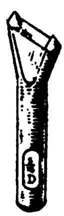


Fig. 552

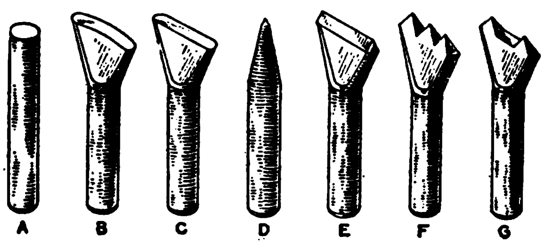


Fig. 553

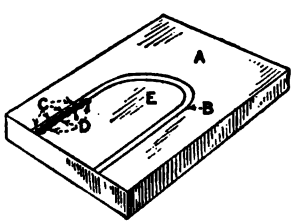


Fig. 554

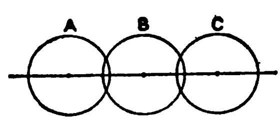


Fig. 555

Figs. 552–555. — The spacing punch and the drilled work

To describe the various steps from a piece of drill rod to the finished article, we will take for an example a center punch with the spacing points $\frac{1}{4}$ in. apart. A piece of drill rod is cut to a convenient length and one end is rounded as at *A*, Fig. 553. The other end is flattened out as shown at *B*. All the other stages — from *C* to *G* — in making this type of center punch are self-explanatory. An 8-in. mill file and a $\frac{1}{4}$-in. square file are the tools to be used for beveling the flat sides and the edges, as at *D* and *E*, and also for filing the nicks. After this has been done, the center portion left by the square file, as shown at *F*, is filed down. The punch will then resemble *G*. The corners left on the two spacing points are now rounded off with a small file, and the punch is ready for hardening. If made of drill rod, it should be hardened, and then drawn to a dark straw color. A

spacing center punch is used only to make a small impression for the regular heavy center punch to follow, so there is no danger of the spacing points breaking off in use. Where a set of spacing center punches of this type has been made, the punches should be stamped on the stem with the size of drill to be used with each punch, as shown in Fig. 552. The sizes can be stamped on after the punches have been hardened and tried out.

A kink worth remembering in drilling stock for parting is illustrated in Fig. 554. The piece *E* is to be removed from the sectional die block *A* by drilling. After a line has been scribed a safe distance from the finish contour of the die, in this case represented by the line *B*, the drill centers are laid out with a spacing center punch and the impression deepened with a regular punch. Every other hole *C* is now drilled clear through the block *A* all the way around. The holes *D* are then drilled the same way, and if the drilling has been properly done, the piece *E* can easily be removed by a few taps with a hammer. The reason for drilling every other hole is to prevent the drill from running off into the next hole. A glance at the layout in Fig. 555 will make clear the point here involved and will demonstrate that the only successful way of drilling holes *A*, *B*, and *C* is to drill holes *A* and *C* first and leave hole *B* for the last.

Fig. 556. — Series of holes in drilling out a die opening

As an actual illustration of a closely drilled die with a minimum of metal in the walls between adjacent holes, the photograph, Fig. 556, is presented here. Examination of the die blank under the microscope will show that only the thinnest wall, a few thousandths of an inch at the most, is left between holes, so that the center is easily knocked out and very little stock left for finishing down to the die outline.

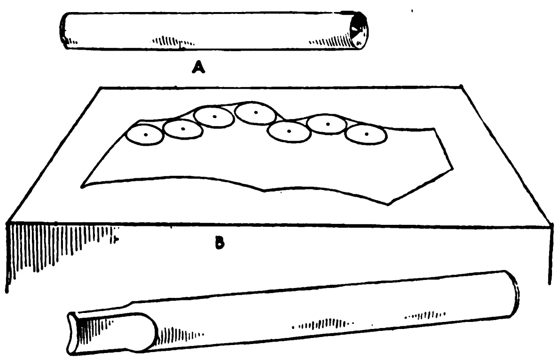
The Circle Marking Center Punch

With the spacing center punch described above it is of course necessary to draw a model line, then a line as a guide for the punch, which means quite a little additional work where the outline is at all irregular. The type of punch which marks its own circle for a guide is made as follows:

Put a piece of drill rod, 0.015 in. larger than the drill to be used, in a spring chuck in the lathe and with a lathe tool or graver form a fine point in the center; also a sharp outer edge, as shown at *A*, Fig. 557. Harden and draw, and it is ready for use.

After drawing the blank outline on the die block, put the sharp edge of the punch on the line and tap lightly, which leaves a center punch mark and circle to which the punch is set for the next hole, as shown at *B*.

After drilling, there is a web left between the holes; to remove this make a drift from drill rod twice the diameter of the drill used minus



FIGS. 557–558. — Spacing center punch and drift

0.015 in.; file or mill it on two sides to 0.010 in. thinner than the drill, round the other two sides to approximate the drill radius, put a slight con-

FIG. 559. — Circle marking center punches

cave in the end, as shown at *C*, Fig. 558, harden and draw, and it is ready to use.

To remove, or rather separate, the pieces and at the same time remove the web, drive the drift through the perforated places and the piece will come out and leave 0.0125 in. for finishing.

A set of these center punches for various sizes of circles are represented by Fig. 559. These range from a size which will mark the circle for a $\frac{1}{16}$-in. drill to a size suitable for a $\frac{3}{8}$-in. drill.

Drills and Drifts

The half tone, Fig. 560, shows a set of spotting drills for various uses in die making, including the starting of holes in drilling out dies prior to running twist drills through.

The tools in Fig. 561 are a set of drifts for cutting out the walls between drilled holes as required in removing the stock outlined by the series of

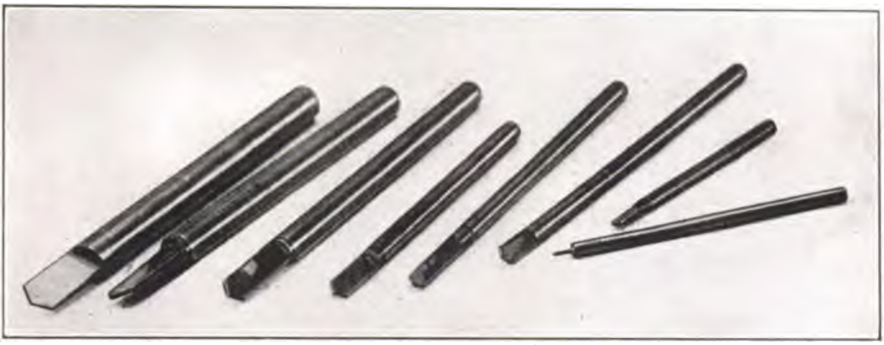


Fig. 560. — Spotting drills

Fig. 561. — A set of die drifts

holes inside the die contour. These drifts are made in accordance with the experience of many die makers who find that the wedge shaped section of the drift gives a freer cut and enables the drift to clear and free itself as it is driven through the walls between adjacent holes. Most of these drifts are short and without shanks, being formed to uniform shape from end to end and they are therefore stiff and rigid under the action of the hammer applied in making the separating cut.

Some of these drifts will be seen to have a decided angle of slope from back to front of cutting edge and in this case they are adapted for cutting

out where holes of different sizes have been drilled as in stocking out the material, between, say, the teeth of a wheel die, where it may be possible to drill two or more holes between top and root of tooth with drills of decidedly different diameters. Wherever there is marked reduction in the width of the slot to be formed, the sharp wedge sectioned drifts are extremely useful.

Working out the Die Opening

The method of finishing the interior of a die after the stock has been removed from the inside of the drilled outline may be by milling, shaping, and filing, or by a combination of operations on the lathe, miller, shaper, slotter, and filing machine. Frequently the die is of such form as to admit of the grinding of a good share if not all of the interior after it has been hardened. This may be done on the regular grinding machine, the internal grinder, or with a traverse spindle grinder, depending upon the size and general character of the work.

A typical example in working out the inside of a die is represented by Fig. 562 which shows the work set up under the adjustable ram of a slotting attachment where the oblong opening of the blanking die and the half round portion at one side are being shaped as indicated. The head for the slotter attachment on this machine is adjustable to give any desired angle for die clearance, either one-half degree or more according to requirements. The die is shown here, however, secured to an adaptor plate which is itself planed off on the bottom to a half degree slope for general use in machines where adjustment of the tool slide is not possible and so the ram in this instance is set in perpendicular position.

Advantages of the Adaptor

This adaptor or sloping holder for the die has been found a convenience in many cases aside from its application to the holding of dies under some such condition as that illustrated. For example, when a die or punch is to be ground with shear for facilitating its cutting action the sloping holder enables the work to be set up on the surface grinder and gives at once sufficient angle for the work to be faced to the requisite angle of shear as generally desired. The half degree slope, while seemingly slight, amounts to an actual slope of about 0.009 in. per in. of length so that a punch say, 7 in. across from end to end, would be ground to a total shear of $\frac{1}{16}$ in. An illustration of this method of using the appliance is given in Fig. 563 where a large blanking punch is seen in place for the grinding of its face to the angle specified.

Another application is seen in the instance of the punch in Fig. 564, which represents a case where a circular disk or washer punch is to be sheared at four points about its circumference. The work is indexed about

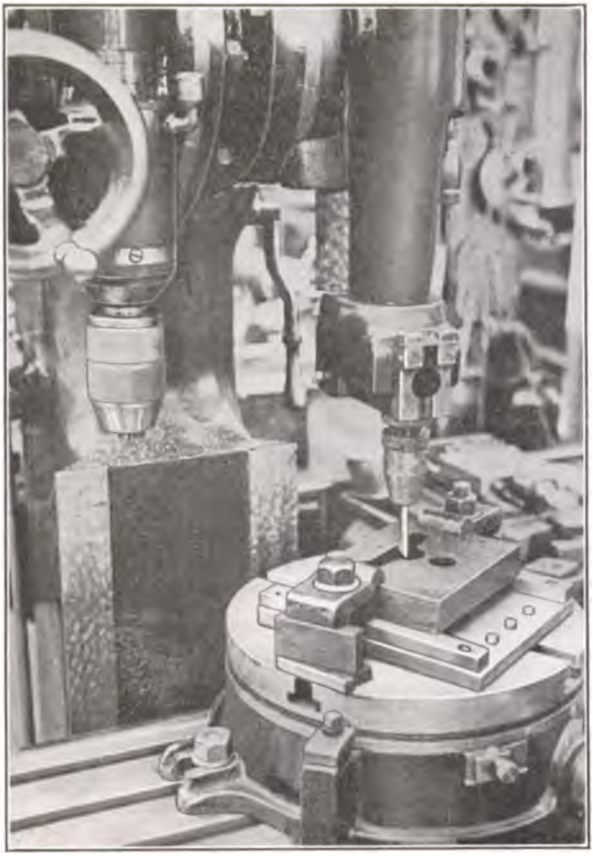


Fig. 562. — Slotting out a die opening

Fig. 563. — Adaptor for grinding shear on blanking punch

its base by turning the holding flange and when passed under the surface grinder wheel, the shear is ground uniformly for each of the four stations to which the punch is set. The high spots at which the four sheared surfaces join are clearly indicated by the four radial lines across the face of the punch.

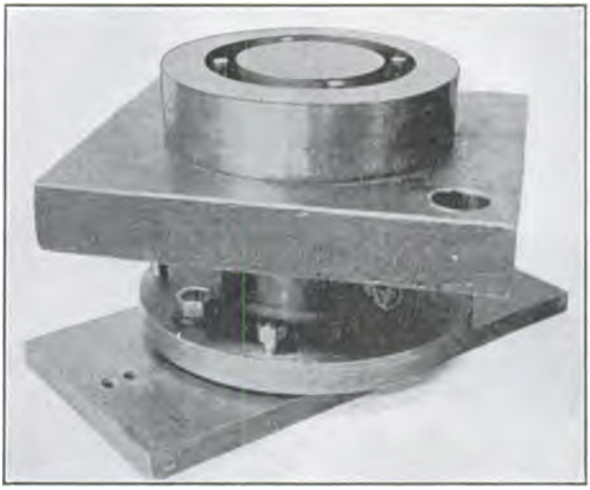


Fig. 564. — Method of grinding shear on face of round punch

Fig. 565. — Die maker's files

The Filing Process

Returning now to the actual work of finishing out the interior of a die opening, we may give a little consideration to the filing processes, hand and machine, which are indispensable in the carrying out of the work of the die maker. The needle files and the die sinker's files on the bench plate in Fig. 565 are of the forms commonly required for die work and with the exception of a very few shapes, the two classes of files are similar in section, but differ in respect to the shank and therefore in the means of holding.

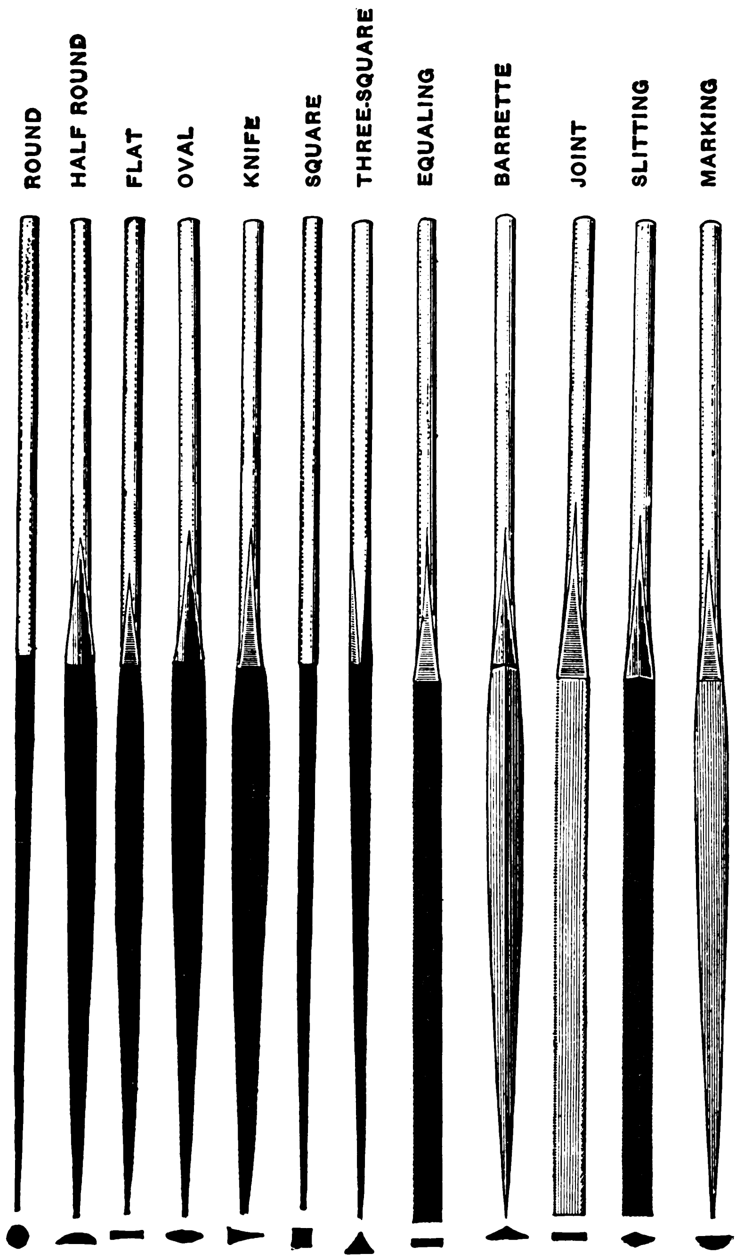


Fig. 566. — Needle files (Disston)

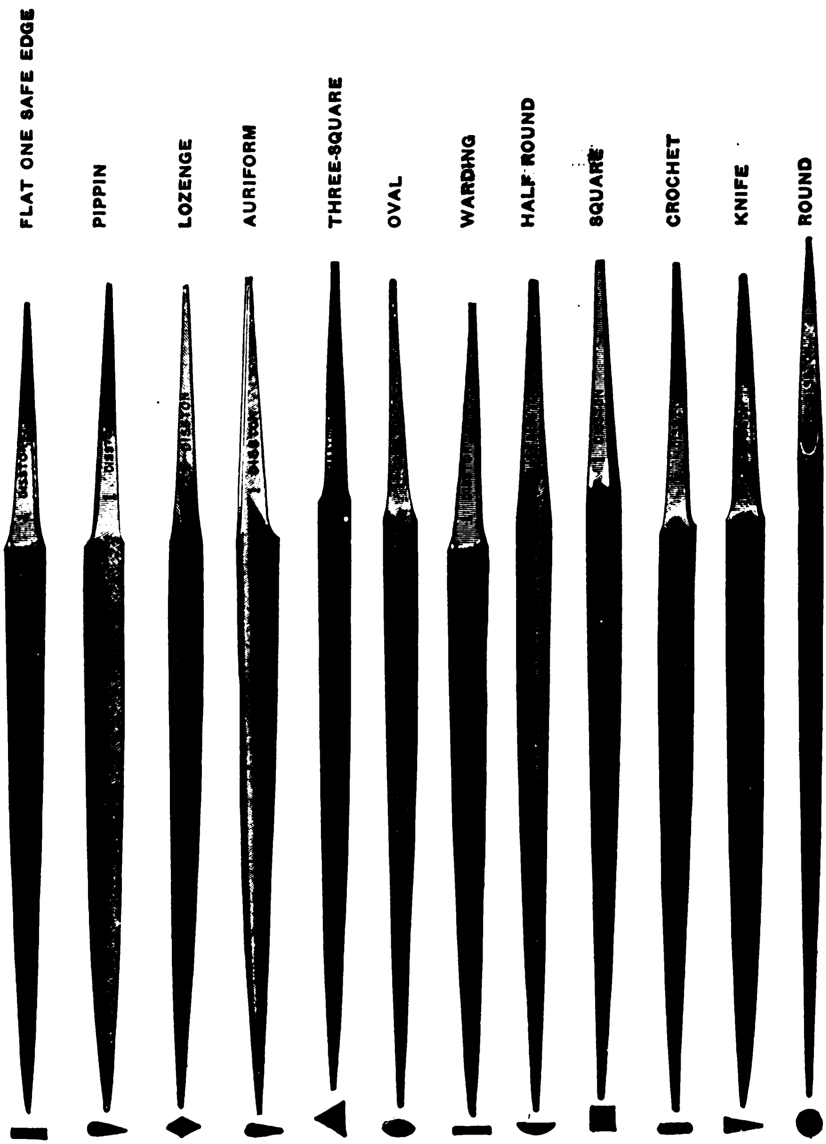


FIG. 567. — Die sinker's files (Disston)

The needle files are made with long slim shanks or round handles about 4 in. in length while the other type, known as die sinker's files, are provided with the usual pointed tang which is used commonly with a small handle that often is nothing more than a disk or wafer shaped affair (as seen in the half tone) which gives a light finger grip.

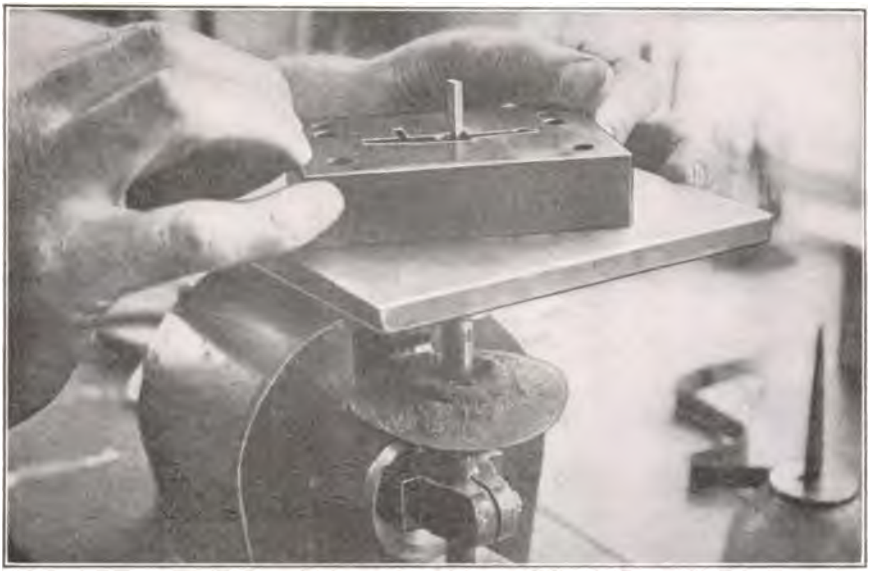


FIG. 568. — Filing out a die opening

FIG. 569. — Files used in filing machine

The two classes of files are shown in detail and designated by name in accordance with their shapes, in Figs. 566 and 567.

The machine filing process has eliminated a large share of hand filing on many classes of dies and greatly expedited the work of the die maker. With the bench filing machine he can watch the outlines of his work and

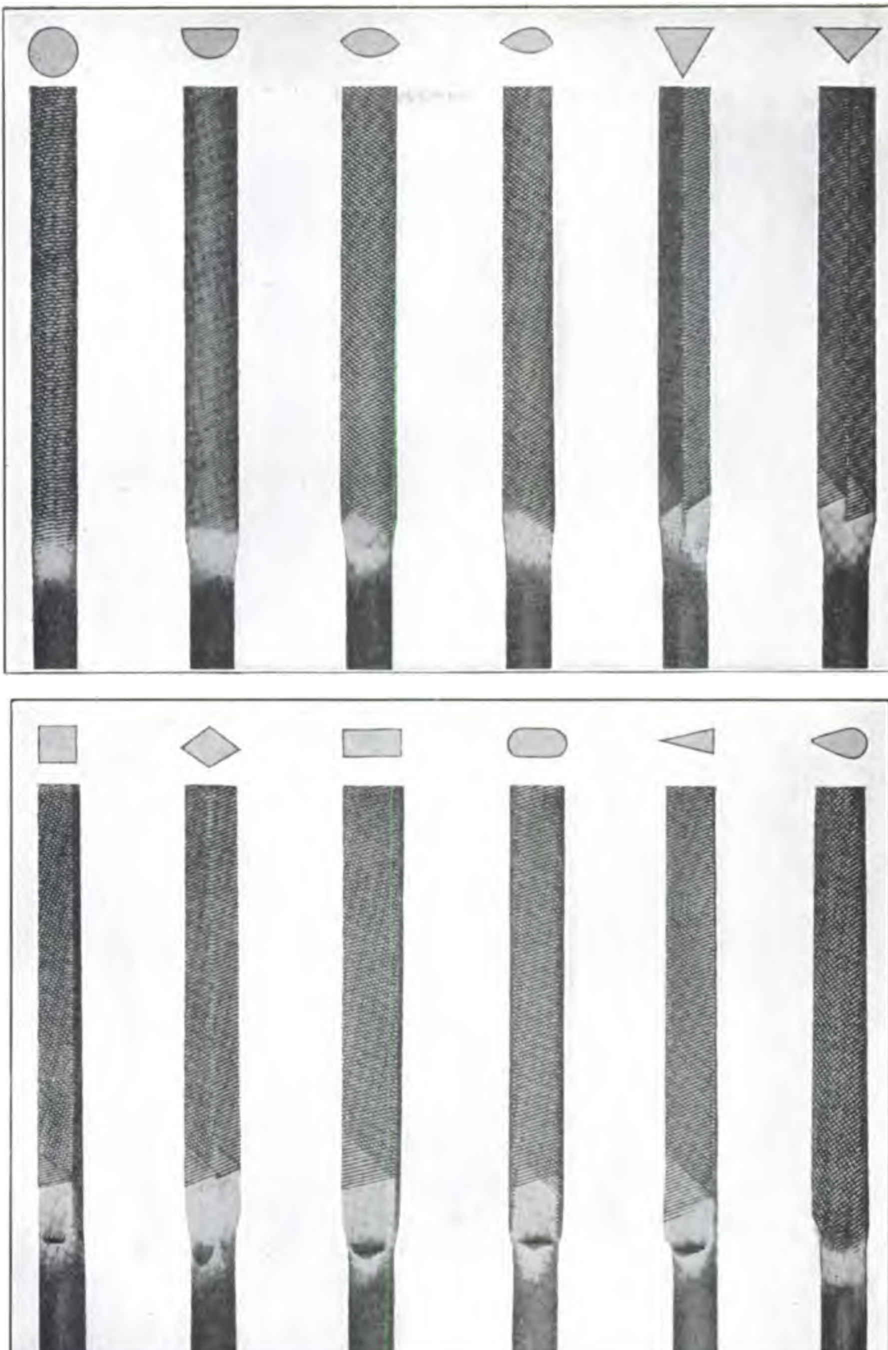


FIG. 570. — Bench filing machine files (Disston) Page 387

with the file mechanically operated he can work the die along the table and remove the stock at the necessary places with little liability of overrunning the outline. And, with the table adjusted to the desired angle for clearance, whether $\frac{1}{2}$ degree or more, he can feel assured that he is holding to close uniformity to this clearance throughout the process, and that he is not likely to secure a bell-mouthed die in the operation.

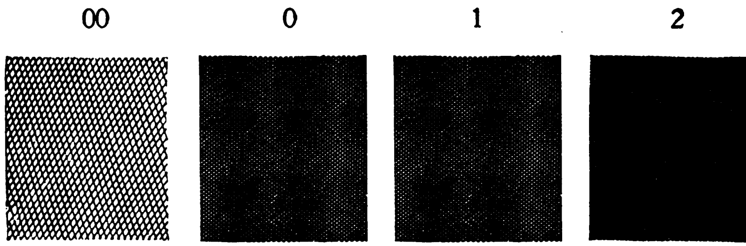


FIG. 571. — Nos. 00-0-1- and 2 cuts for machine files (exact size of cut)

A typical piece of work on the filing machine table is illustrated by Fig. 568. A group of files made specially for such machines is shown by Fig. 569. The shapes of these files with dimensions are given in Fig. 570. Ordinarily they are made in four cuts, or degrees of coarseness. These are designated as Cuts Nos. 1, 2, 3, and 4. The exact size of the teeth for these respective cuts is given in the engraving, Fig. 571.

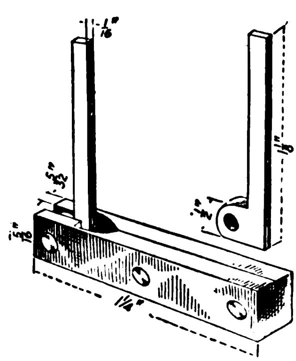


FIG. 572. — Die maker's adjustable square

DIE MAKER'S SQUARES

The die maker has constant use for squares of various kinds in all of his work and particularly in filing out blanking dies and openings of similar character in other tools. The sketch, Fig. 572, gives the principal dimensions of a very handy square which is designed for fairly small work but which may be made to proportions to suit any class of work.

Its special feature is the hole beneath the blade, enabling one to see what sort of contact is made between the blade and the work inside a hole or slot in a die. As the amount of clearance used in different shops varies, the blade is adjustable. The base is made in two parts, so that the sides of the slot holding the blade can be ground parallel. In this way, a fit can be made that will be tight enough to hold the blade in place. While this blade is put in with a rivet, a tapered screw or some other means can be used that will fasten the blade securely and still be easily loosened when it needs adjusting.

A square with this improvement of a screw at the side of the stock for securing the blade in fixed position is shown in Fig. 573. The square referred to is at the left of the group of three in this photograph. The one in the center is the conventional fixed blade tool and the one at the right is a square with blade secured by the knurled nut at the front of the stock. All three squares are very useful parts of the die maker's tool equipment.

Grinding Out Dies

Reference has been made to the possibility of finishing various shapes of dies by grinding out after hardening, and a few views are here shown where the grinding wheel is employed for such operations. Naturally an

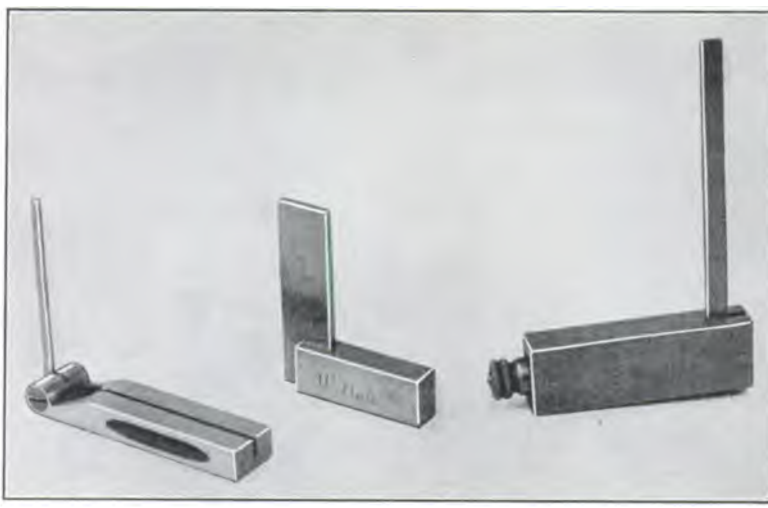


Fig. 573. — Die maker's squares

internal process of the kind mentioned is most readily performed with dies having circular openings, as with round blanking dies, and piercing dies of large enough opening to admit the wheel. But there are numerous instances, also, where the die opening terminates in a rounded end or a round corner or where an arc is formed along the main portion of the contour all of which allow a wheel to be employed to advantage if the size will permit a wheel to be used at all. Then, too, the straight lines connecting circular portions sometimes allow a grinding wheel to be entered to finish these edges with the work stationary just as the circular parts are ground out by rotating the machine spindle.

In Fig. 574, a die is shown set up on the bench lathe face plate for the finishing of the round end of the die opening by the traverse spindle grinder. The die is, of course, located by indicating before securing to the face plate and the work of sizing the portion referred to is then an easy process.

The spindle with the wheel is set around to the necessary angle by the compound rest to provide for the degree of clearance desired inside the die.

The operations illustrated by Figs. 575 and 576 consist of indicating the die in the chuck jaws of the internal grinder and then grinding out the piercing opening. The chuck jaws are faced true with the wheel and owing to the shape of the die there is no difficulty in holding the work satisfactorily

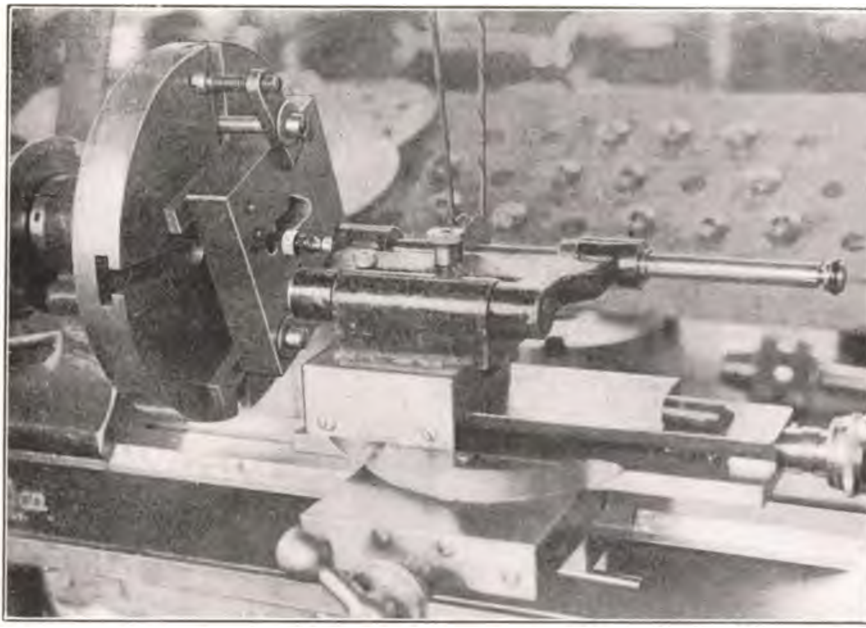


FIG. 574. — Finishing die opening with traverse spindle grinder

in this manner. If necessary it would be an easy matter to secure the die to a face plate and follow the same process of indicating and grinding.

While the operations illustrated are the grinding of the circular piercing opening, the same operation may be performed on the circular enlargement at the center of the blanking die proper. The method of indicating would be the same and the wheel could be applied in exactly the same manner as for the plain cylindrical hole.

OPERATIONS ON PUNCHES

The machining and finishing of punches, consisting as it does of the working of external surfaces, is generally speaking a simpler problem than the making of dies, just as the finishing of the outside surface of any part is usually more easily accomplished than are the corresponding operations necessary to the completion of an internal piece of work. Plain cylin-

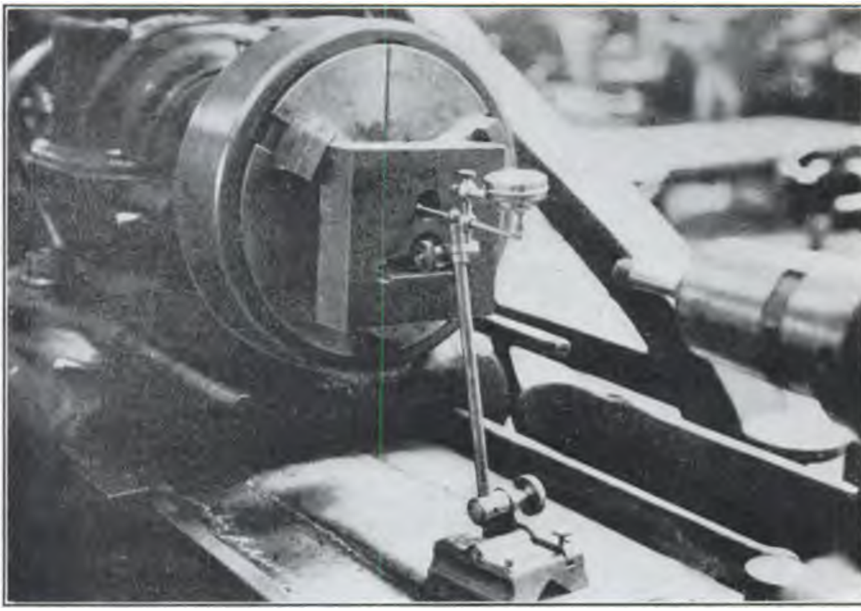


Fig. 575. — Method of indicating die before grinding

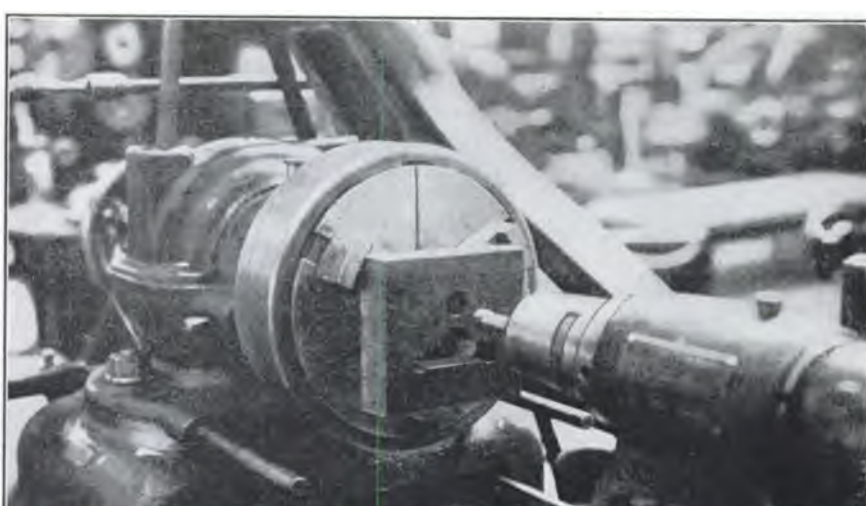


Fig. 576. — Grinding out the die

drical punches and others of regular section are, of course, readily machined and there are various other forms which, although apparently difficult to produce when first considered, yet admit of handling by the elementary processes of the lathe, or the milling machine.

Examine, for example, the punch shown on the lathe carriage in Fig. 577. This is for cutting off flat stock to produce the round end link shown in Fig. 578. It is obviously a lathe or a milling machine undertaking to

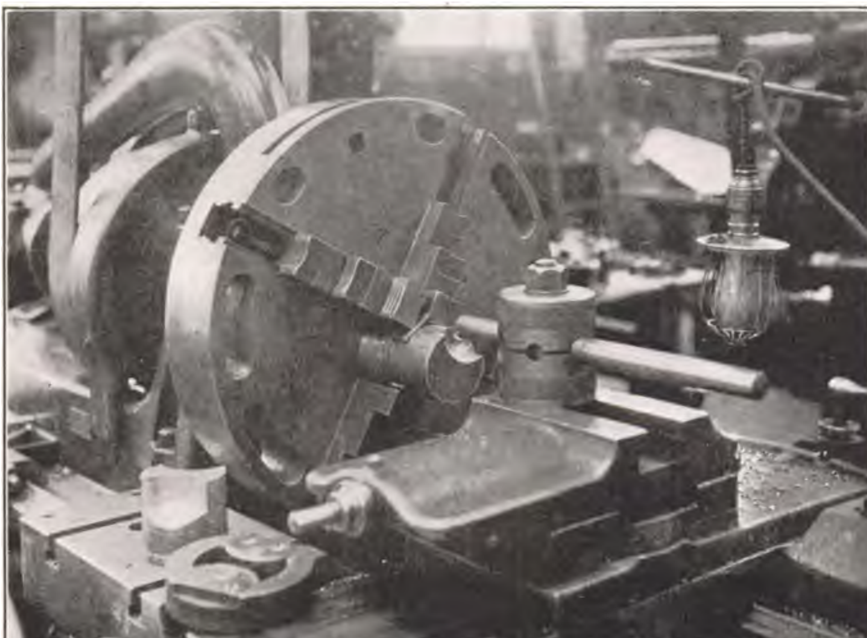


Fig. 577. — Making a punch in the lathe

shape the opposite sides of the punch to the concaved form required. In fact such punches are made in both machines mentioned, but in the case illustrated the lathe is being used for the purpose. The metal which this punch shears is rather heavy and there is considerable clearance between punch and die so that the requirements as to accuracy of dimensions are not exacting, otherwise the punch blank could have been secured in a holder and the latter mounted on the lathe face plate for assuring a closer adjustment in setting for the two cuts to be taken on the opposite sides of the work.

In this instance the punch is shown gripped in the four-jaw chuck and offset from center the right distance for the turning out of the side to the necessary arc for rounding the cut-off link properly. Upon completion of the first side the chuck jaws are set over to throw the work the same

distance the other way from the center for the boring out of the second concave form.

The die is seen at the front of the carriage. A die of this form, if solid, requires considerable time in the working out of the opening. If made in sectional form as in Fig. 578 the parts are turned out without difficulty, the ends *AA* being bored as readily as a ring, and the side pieces *BB* turned and let into their places after which the outside portions are turned to match the diameter of the die as a whole.

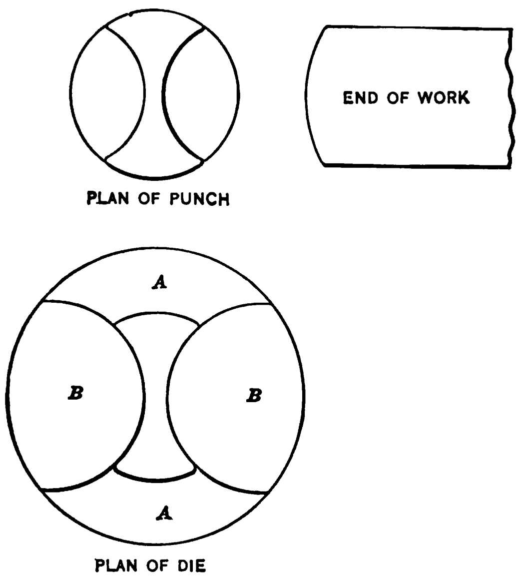


FIG. 578. — Punch and die for cutting off links with rounded ends

A milling machine operation on a punch of crescent form is shown by Fig. 579. Here the work is seen set up on the face plate of the dividing head and the interior cut is underway. The outer surface has already been milled down closely to the outline scribed on the punch face and the inner cut will be similarly brought close to dimensions before the punch is removed from the machine. The cutter is held in the spindle of the vertical milling attachment which is here swung to horizontal position, and the work is fed past the cutting teeth by rotation of the dividing head crank.

Larger Die Work

A method of machining a large set of dies is shown by Figs. 580 and 581. These dies are similar to certain sets illustrated in other sections of this book. They are of elliptical form and have a long diameter of about 18 in. The parts being machined in the lathe are of cast iron and these castings when finished are fitted with tool steel cutting rings which

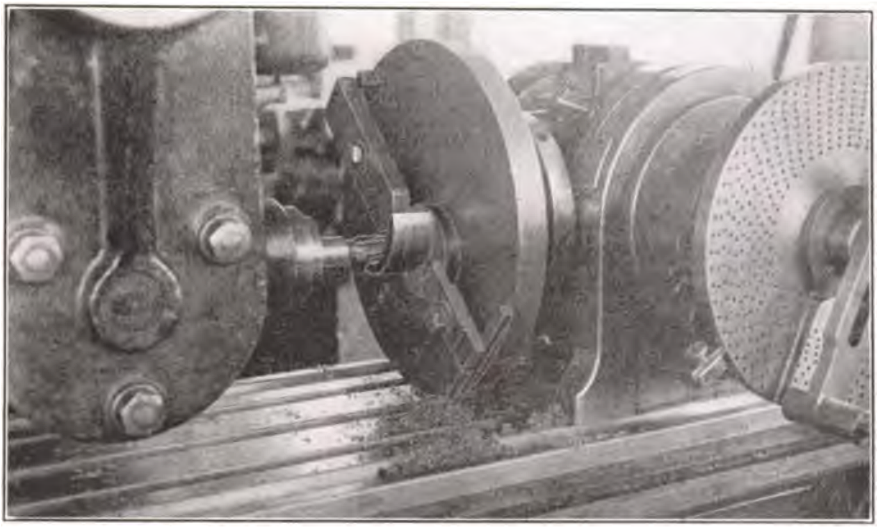


Fig. 579. — Milling a crescent shaped punch

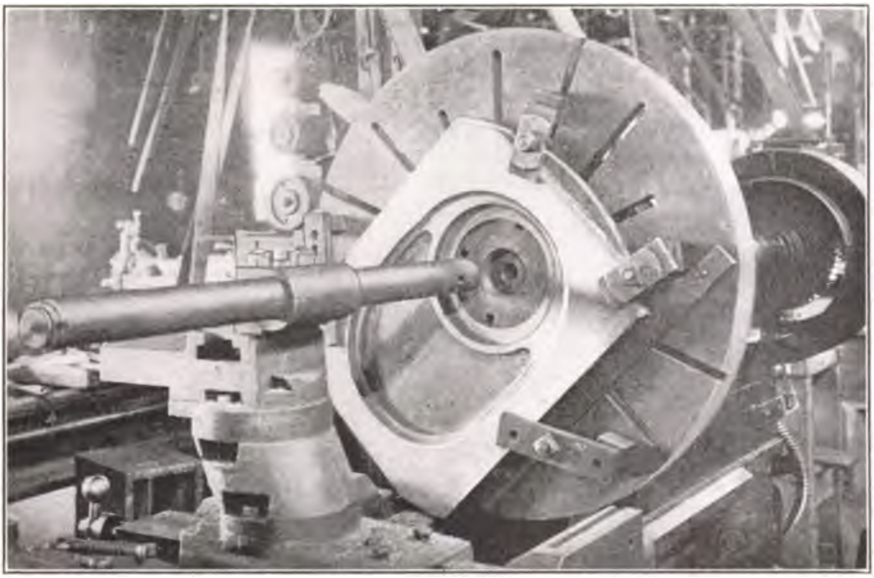


Fig. 580. — Making large dies

are shrunk or pressed into place according to whether they are fitted to the male or female die.

The point brought out by the illustrations is the method of locating on the faceplate of the lathe by means of a parallel along which the work may be adjusted for position for the boring operations at opposite ends. In Fig. 580 the die is represented in the operation of boring of the circular

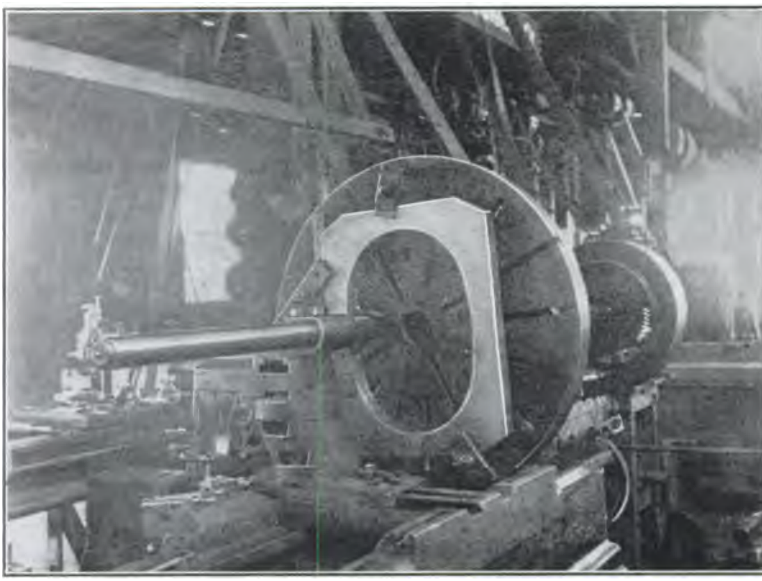


FIG. 581. — Boring out large die

portion at the right of the center. For boring out the ends to larger radius the work is moved along the parallel and reclamped at the right distance from the center to give the position for sweeping out the metal at the end of the cored chamber. For the opposite end of same radius the work is simply reset at the same distance from the other side of the center. The turning out of the still larger curves at the sides is accomplished as with the die member seen in Fig. 581, where the curve is swept out to join the arcs of shorter radius already finished.

Elliptical attachments for the lathe have been used for such work with success but they are not always available when special work comes along that has to be put through the shop in the least possible amount of time.

CHAPTER XVIII

LOCATING HOLES ACCURATELY IN DIE WORK

The problem of locating holes in dies with the degree of accuracy desired is sometimes a difficult one, particularly where no special means in the way of a vernier equipped drilling machine or other tool of similar purpose is available. The small holes often required in piercing dies and in progressive piercing and blanking tools are generally more difficult of location if extreme accuracy is essential, than where holes of fair diameter are to be bored. For the small dimensions of the holes (and often of the die itself) may render the usual type of button unavailable for the purpose. Owing to the fact that the button holding screw cannot be made smaller than a certain minimum it may be larger than the hole to be bored, and even though the die is to be bushed so that a larger hole is permissible, the close center distance between holes may make it impracticable to button up the work in the manner followed with similar problems where there is more space between centers.

Aside from the necessity for many such holes in connection with piercing dies, there are some shops where it is customary to outline all blanking dies by means of small holes drilled at the corners, and at the ends of lugs and projections. These holes then form the limiting points to which all outlines in the die must be carried. They must be correctly positioned or the die will be inaccurate. They are usually of necessity quite small in diameter for often they are used for the additional purpose of leaving a small fillet in the die corners to produce a similarly small rounded corner on the corresponding part of the blank. Where a perfectly square corner on the work is not necessary this practice undoubtedly results in a better appearing blank and a stronger corner in the die. Under certain conditions, as stated above, it may add to the difficulties of making the die in the first place, but under other circumstances where holes are not too closely spaced and where suitable toolroom equipment is in use, the practice referred to may be of real aid to the die maker, who thus establishes at the outset all limiting points in the work to which all contour elements of the die must be held.

An illustration of a blank of this kind is presented in Fig. 582. At A is shown the blank with the radius of each corner and fillet specified. The layout of the holes to be first drilled in the die block is given at B. The

outline of the die opening to be worked out after the holes have been drilled is indicated by the dotted lines.

The centers of the holes may be laid out by vernier height gage as shown in the previous chapter, with the die block clamped to an angle plate on the surface plate and the centers at the intersecting points of the scribed lines can be marked by a center punch and then drilled, or indicated on the faceplate of the lathe and drilled in the machine. Or if

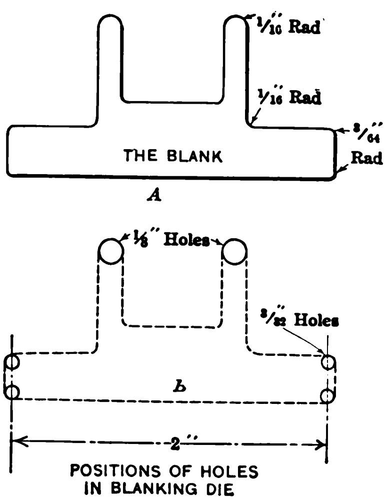


Fig. 582. — A blank and the location of limiting holes in the die

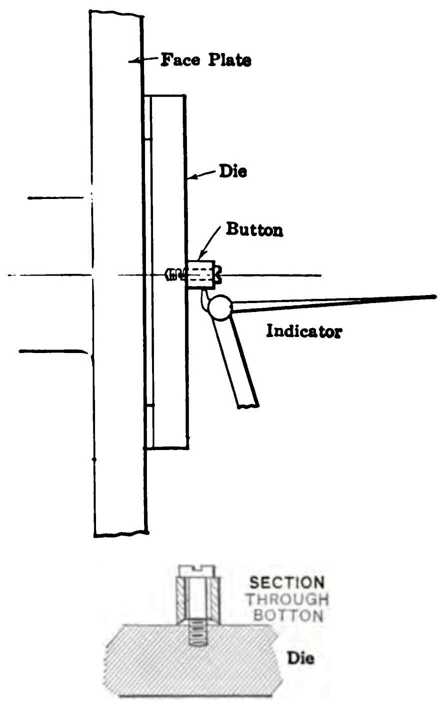


Fig. 583. — Application of the locating button and test indicator

space is sufficient the button method may be employed as in Fig. 583 and each hole indicated as shown and bored to exact location and size. The buttons are, of course, set in position on the die by measuring across with micrometers or other precision tools.

Application to Progressive Dies

A good illustration of the principles involved in the making of a progressive die with several small holes therein can be gathered by following the different stages in connection with the tools for a clock part shown in Fig. 584.

From this sketch it will be seen that a tolerance of only 0.0005 in.

either way is allowed for the center distances of all three holes. The circular rack A is rough blanked in the same die, sufficient stock being left for a finish shaving operation in another die.

The layout of the first die is given in Fig. 585. The blank, which is No. 19 gage (0.0437 in.) cold rolled steel, does not have to be held to close limits, with the exception of the circular rack part. As this is finished in a later operation, the spacing of the three holes with sufficient accuracy comprises the real problem in this case.

The die opening A, Fig. 585, is worked out to a model and the $\frac{7}{16}$-in. holes B, C are bored part way through the die blank, the clearance holes being large enough for the full passage of slugs.

Two pieces of drill rod $\frac{7}{16}$ in. in diameter by $\frac{7}{16}$ in. long are next driven into these holes, and two $\frac{1}{8}$-in. holes are drilled and reamed halfway into

FIG. 585

FIG. 584

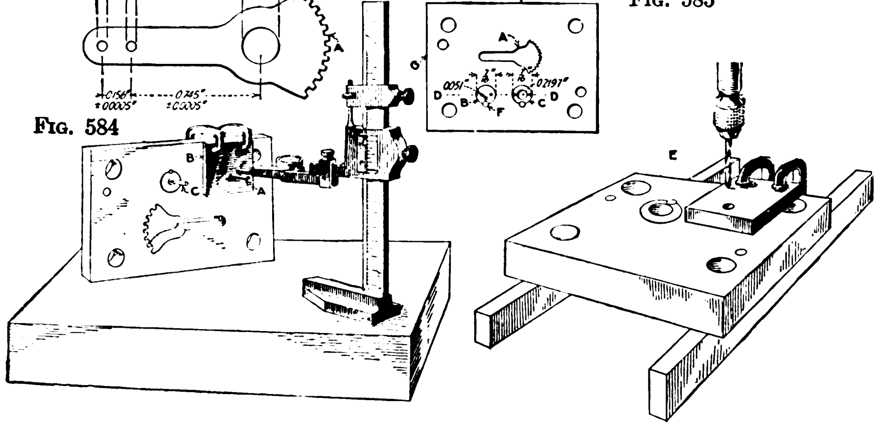


FIG. 586

FIGS. 584–586. — Locating small holes accurately in dies

the die blank and the drill-rod plugs, as at F. The plugs are next removed, and the die blank, with the finished die opening A, is hardened. After hardening, this die opening is honed and retouched to fit the model. The drill-rod plugs, together with $\frac{1}{8}$-in. dowel pins in holes F, are driven in, and the die blank is ground parallel on both faces. Also, the edges G and H are ground square, the edge H being parallel to the center line of the three holes. Grinding the edges G and H facilitates locating the button and the drill plate while the die blank is resting on those edges on the surface plate, as will be shown later.

Next the plug in the hole C is drilled and tapped for the button screw, and the button is set to the correct location by the usual method, using an indicator in the height gage and taking the necessary measurements from points of the finished die opening. The button thus secured is trued

up, and the 0.2197-in. hole is bored out in the lathe. For the two 0.051-in. diameter holes the following method is employed: A piece of $\frac{3}{16}$-in. flat cold-rolled steel is drilled so that a 0.051-in. rod is a good sliding fit in the hole, after which the cold-rolled steel plate is cyanided.

Work on the Insert

Fig. 586 shows the successive steps in locating and drilling the two 0.051-in. holes in the inserted drill-rod plug in the die blank. With a 0.051-in. plug *A*, Fig. 586, in the drilled hole of the cyanided plate *B*, and a plug *C*, consisting of two diameters — namely, 0.2197 in. and 0.051 in. — concentric with each other (a good fit in the previously bored hole of the die), locating the plug *A* correctly for one of the small holes is but a matter of measuring with micrometers and the height gage from plug to plug, testing with the height gage as shown.

After the plug *A* with the plate *B* has been tapped into place, the plug *A* is removed and the die blank, with the drill plate held securely with clamps, is taken to a drilling machine. At *E*, Fig. 586, is shown the die blank resting on parallels on the table of the drilling machine, preparatory to drilling the 0.051-in. hole. It might be said that the hole is first spotted through the drill plate with a 0.051-in. drill, then drilled right through with a drill a few thousandths less in diameter and finally reamed with a 0.051-in. twist drill, which has the corners rounded so as to produce a smooth hole. The drill plate is next removed and the remaining hole treated identically.

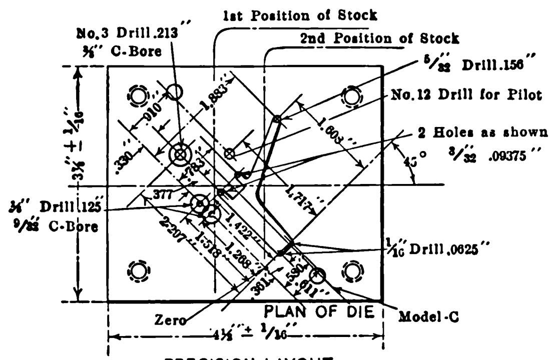
All three holes are now taper reamed from the back for clearance; both $\frac{7}{16}$-in. drill-rod plugs are removed from the die blank and hardened, after which they are again pressed back in their respective holes, the $\frac{1}{8}$-in. dowels lining them up to positions they occupied while being drilled and bored. A slight finishing cut is taken over the die face in the surface grinder, thus completing the die blank. The punch holder plate for this die is drilled by the same method; and the blanks, when they come from this punch and die, are well within the limits specified. In cases where one of these drill plates is to be used frequently, it is a good policy to make them out of hardened tool steel; a piece of ground tool steel stock does nicely for this purpose.

The method just described is a very valuable one in shops where the equipment is not of the best, but where the quality of work turned out is expected to be first class.

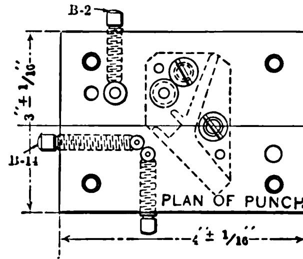
The Precision Layout

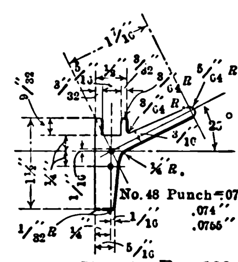
In some factories the drawing office supplies the die maker with a complete layout of the tools required so that the centers of all holes are given in thousandths of an inch from one starting point which once located

forms the zero mark from which every hole is accurately spaced. The drawing in Fig. 587 shows a progressive piercing and blanking die for the blank in Fig. 588 with all holes located in reference to this zero point.



PRECISION LAYOUT
67 TOOTH RATCHET FEED-5 TEETH-STEP 820"
STOCK-.025" X 2 5/8" X COIL SPRING STEEL





BLANK FIG. 588

.025" Spring Steel
2 per Mach.

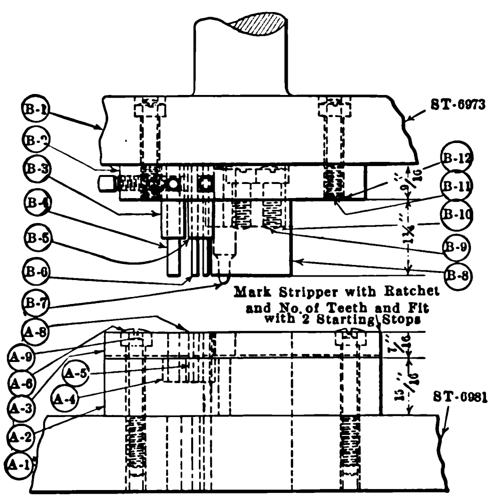


FIG. 587

B-14	1	1/4"x 1 1/4" Sq. Hd.	Set Screw
B-13	2	1/4"x 5/8" Sq. Hd.	Set Screw
B-12	4	5/16"x 1 1/2" Fil. Hd.	
B-11	2	3/16"x 1 1/8" D. R.	Dowel
B-10	2	3/16"x 1" D. R.	Dowel
B-9	2	5/16"x 3/4" Fil. Hd.	
B-8	1	1 3/8"x 3"x 1 3/8" T. S.	Punch
B-7	1	3/8"x 2" D. R.	Pilot
B-6	2	.075"x 1 1/8" D. R.	#48 Punch
B-5	2	9/32"x 1 1/4" D. R.	Bush
B-4	1	3/16"x 1 1/8" D. R.	Punch
B-3	1	3/8"x 1 1/4" D. R.	Bush
B-2	1	5/8"x 4"x 3" M. S.	Punch Plate
B-1	1	ST 6973	Stock
A-10	1	ST-6892	3/4" Guide Pin
A-9	1	ST-6895	15/16 " "
A-8	2	5/16"x 7/16" D. R.	Bush
A-7	2	1/4"x 2 3/8" D. R.	Dowel
A-6	4	5/16"x 2" Fil. Hd.	
A-5	2	1/4"x 7/16" Drill Rd.	Bush
A-4	1	3/8"x 7/16" Drill Rd.	Bush
A-3	1	1/2"x 6"x 4" M. S.	Stripper
A-2	1	1"x 4"x 4 1/2" T. S.	Die
A-1	1	ST-6981	Stock
No	Quan	Material	Remarks

FIGS. 587–588

This is a typical layout as made by the Smith Premier Typewriter Company for use in connection with the precision drilling machine made by them for use in their tool room. The same principle however can be adapted for service in tool rooms having a milling machine with vernier scales attached for the table and knee movements, although naturally the

special drilling machine noted has certain advantages for this peculiar class of work not to be expected of the general purpose tool room miller.

The precision drilling machine has a vertical spindle mounted in a slide with power mechanism for feeding the drill through the work. There is a rigid drill support which guides the drill at the point of cutting and the work is held on a table which closely resembles in design and operation the table of a milling machine, as it is fitted to a saddle on a knee of the miller type and has therefore all of the movements of the miller table. The machine is built with extreme accuracy and its performances in the correct locating of holes in dies and similar tools are remarkable not only because of the degree of accuracy obtained in the work but also because of the rapidity with which it accomplishes its operations. The table and saddle are equipped with vernier scales. The drill support is equipped with a set of hardened and lapped bushings varying in diameter of hole from No. 54 drill size to ¾ in. Holes as large as 2 in. can be bored by means of an eccentric boring tool. A general view of this interesting precision tool is presented in Fig. 589.

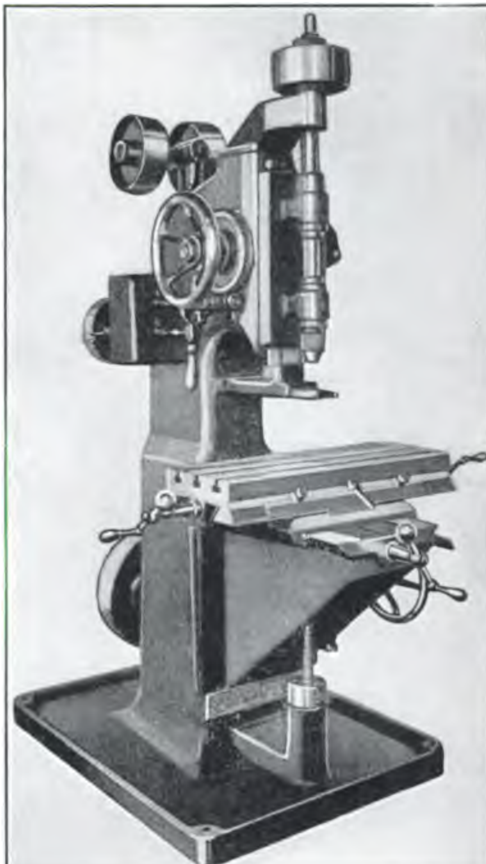


Fig. 589. — Precision drilling machine

How the Precision Layouts are Used

The toolmaker in charge of this machine is assisted considerably on the job by the provision of the precision layout by the drafting room. The layout is made at the same time the tool is drawn up and gives, for the sake of clearness, merely the information needed to perform the precision drilling. Samples of these layouts are shown in Figs. 587, 590, and 591. The toolmaker clamps the work to the table and brings the work under the spindle so that the latter is directly over the zero point as indicated on

the layout. The zero point may be scaled from the edge of the work, as is necessary in Figs. 587 and 590, or it may be at the corner of the block. When the drill spindle is over the zero point, as shown by an indicator in the chuck, the scales on the table and spindle are set very carefully at zero. The holes on the layout are all located in thousandths from the zero point in two directions, thus enabling the toolmaker to complete the drilling without resetting the scales. The rest of the operation is simple, the toolmaker carefully moving the table until the scale readings correspond to the coördinates as given on the layout and then selecting the proper bushings, drill, and reamer to complete the hole. Care is taken to have the work close to the drill-support slide so that the point of the drill is steadied as it enters the work. To change the drills the drill is raised from the bushing, the slide unclamped and pushed back in the frame and the drill taken out.

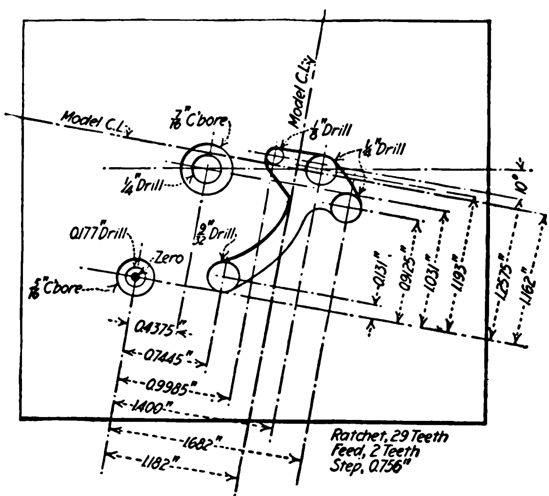


Fig. 590. — Layout for blanking die precision

The use of the scales permits the exact location of the work in relation to the drill spindle regardless of any backlash or wear in the lead screws. The drill support, which insures the drilling of the holes in the exact spot required, is used only until the drill is started in the work. Then it is moved back and the hole drilled. This is done to reduce the wear in the bushings. The reaming is done through the bushings.

The precision drill has been used effectively in the laying out of dies and in the removing of stock from die blocks. It is equally effective in locating bushing holes in drill jigs. It has also been of great assistance in the making up of models prior to the starting of regular production.

In Fig. 590 is shown a good example of the layout for a blanking die to be used in a press with automatic feed. The exact location for the holes for piercing punches and leaders in the die block is thus quickly provided. The layout in Fig. 590 is shown with the axes at an angle of 10 degrees with the side of the die block. This does not lengthen the operation on the precision drill as the stock can be clamped on a swivel table and turned to the required angle quickly. The work of preparing the layout, however, is considerably decreased as the axes are parallel to the center line of the

part drawing and therefore the calculation of the coördinates is simplified by merely having the block turned at the required angle.

In Fig. 591 is shown an example of a die block with a large part of the stock removed on the precision drill. This die is subjected to severe service and requires frequent replacement. Consequently it is considered economical to provide a very complete precision layout giving ordinates and drill sizes so that the finishing time for the die would be materially reduced. The irregularity of the form of this die would make a difficult task of laying out for drilling by the die maker in a sensitive drilling machine. The irregularity of form would also increase the probability of error and the consequent spoiling of the die by the diemaker. The precision drill, however, takes care of this job in a very simple fashion, and the work comes to the diemaker in a manner that requires the minimum of stock removal.

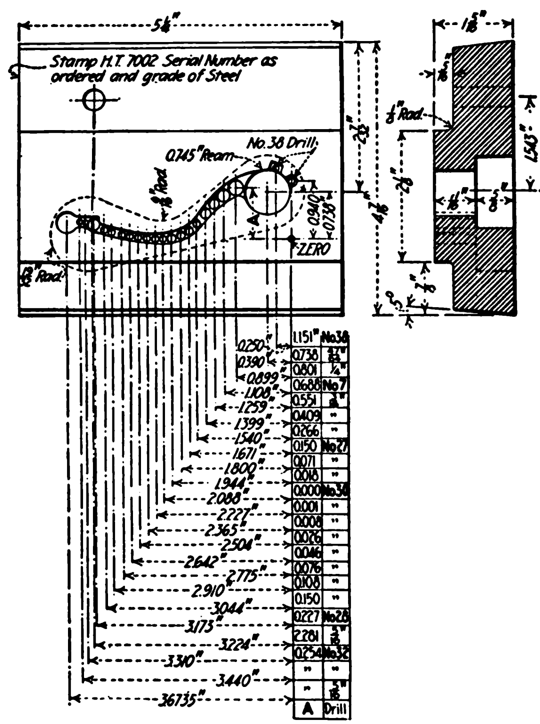


Fig. 591. — Precision layout for blanking die

The use of the precision drill for Fig. 591 does away with the necessity for making accurate templets for laying out the curved edges of the die.

The Use of Master Plates

The master plate is a device well known to tool makers engaged on high class work. It has numerous applications in various branches of tool work but is less frequently employed in connection with the making of dies and punches than with certain other lines of precision work, although there is no tool room branch where it can be used more effectively than in the construction of press tools.

There is perhaps a certain amount of misunderstanding in regard to the making of such plates that tends to prevent the extension of their uses to the full in connection with die construction as well as in some other directions. It has been found a more or less common belief in some classes of

shops that the master plate is specifically a watch tool maker's device and that it is limited by first cost and unnecessary refinement to the needs of the watch factory tool room and similar departments in other shops doing practically the same kind of work.

This belief, while a commendation of the superior qualities of the master plate, is unfortunate in so far as it may have delayed the adoption of this most convenient device in different tool rooms and for various grades of die work. The master plate is truly a tool of precision, assuming it is made with the degree of skill and care which it merits; but it has its legitimate uses in other places as well as in such tool rooms as turn out only the highest grade of precision work. And if toolmakers but stopped to realize that the purpose of the master plate is to make possible exact duplication of its own qualities of accuracy, whether that accuracy is of the highest or of only moderate degree, they would see many opportunities to employ it to advantage where now they only too frequently leave it entirely out of consideration so far as the greater part of their work is concerned. This is true to an even greater extent with diemaking than in general tool room practice.

Now a jig is a device for duplicating within the running limits of drills and reamers, the center distances established by its own guide bushings. If these distances are accurately determined in the construction of the jig, the parts that are drilled therein will be as close duplicates in respect to hole locations as the operation of the drills will permit. But if we are seeking for a perfectly true job of boring with holes as straight and round as possible, and if moreover we wish to secure the closest accuracy in the relative locations of two or more such holes, we will naturally resort to some form of face plate process where the work can be swung as in a lathe and where after the centers of the holes have been indicated with a test indicator the work can be drilled and then completed by rotating it on its own axis while a boring tool is applied until the hole is finished to the desired diameter.

The master plate is essentially a face plate appliance. It enables us to mount our work on the face plate and secure for each and every hole bored out the exact degree of precision in location that is represented by the master itself. A center distance established in the master plate is reproduced exactly in the work and if a duplicate job arises at any time it is bored out with the same degree of exactness as was obtained for former pieces.

In its application to press tools, it enables the die maker to bore punch plates and dies as precise duplicates of each other with the assurance that the center distances thus obtained will bring the tools into positive alinement when assembled. The replacement of either punch plate or die, or both, at any time is readily accomplished with the aid of the master plate

and there will be no question as to the preservation of the original center distances in the newly made parts.

Whatever the qualities of the master plate as to accuracy, these are transferred to the work. If a set of dies is required of unusual degree of accuracy, the master plate will be found a most effective agent in the carrying out of their construction. If on the other hand there is no demand for precise location of hole centers, but replacement of the tools is a deciding factor, the master plate will prove fully as effective as in the other case.

Thus far we have considered the master plate as of service in the locating and boring of holes only. It is equally valuable as an aid to the correct working out of various regular and irregular die openings and punch forms on the lathe and in the milling machine.

Illustration of a Master Plate

As an illustration of a simple master plate and its application to a piece of die making let us refer to Figs. 592, 593, and 594. The master plate will be seen to be a plain block of steel in which a series of holes are accurately bored to suit certain center distances required in the die.

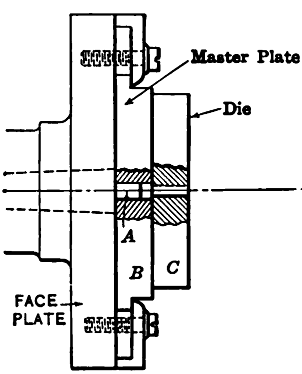


Fig. 592

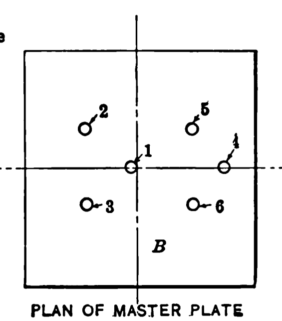


Fig. 593

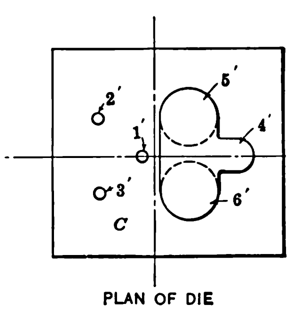


Fig. 594

Figs. 592–594. — The use of the master plate

In use the master plate is placed on the bench lathe face plate as in Fig. 592 where it fits snugly over a hardened and ground center plug A placed in the taper hole in the lathe spindle. The master plate B may be secured by light straps and screws as indicated or by other clamping means, but it is obvious that it must seat squarely against the perfectly true face plate and be held there without being sprung or deflected.

The work, the die C, is secured by screws and dowels or if quite small may be soldered to the face of the master plate. With hole No. 1 of the master plate located over the center plug A, the work is in position for the boring

of the hole 1′ in the die. When shifted to hole 2 the plate brings the die block into position for boring hole 2′ and so on until the work is completed.

In the illustration, the die has three holes (1′, 2′, 3′) for piercing and there are three locations (4, 5, and 6) for setting the die for the boring out of the enlarged circles 4′, 5′, and 6′, for the blanking opening. These larger holes are bored with the same accuracy and convenience as the small piercing holes, and after they are completed, the plate and work may be transferred directly to a miller for finishing out the die opening, to the full lines of the sketch.

The punch plate may be handled on the same master plate for the boring of the holes for the piercing punches and the blanking punch can be

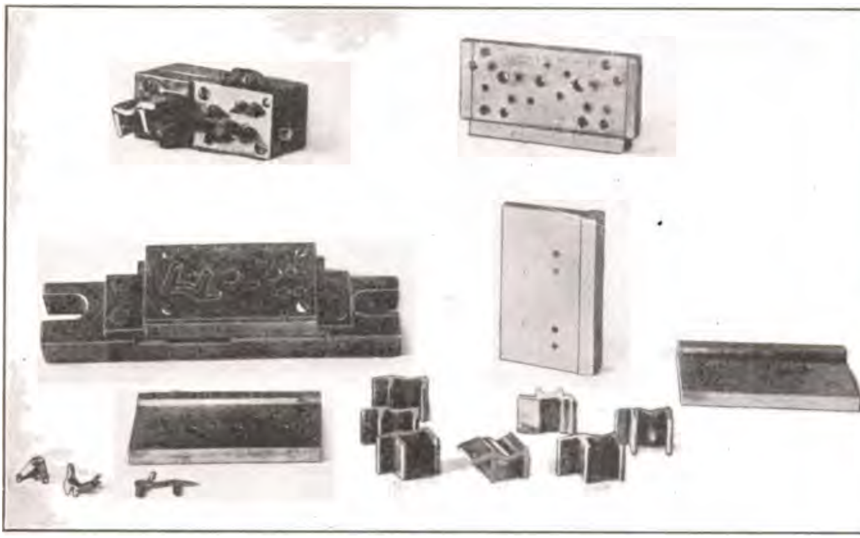


FIG. 595. — Master plates for die work

milled up to form by mounting the master on the dividing head face plate and rotating it to swing the work past the milling cutter for the rounding of the three lobe ends. Held in the same place with the work revolved to horizontal or vertical position the straight surfaces of the punch can be milled to desired dimensions.

A blanking die with most irregular opening can usually be worked out from a master plate without difficulty by providing a locating hole in the plate for each arc and curve in the die opening.

With a master plate once made, a complete set of dies, piercing, blanking, shaving, etc., can all be made to uniform centers for accuracy of spacing by handling each in turn on the same master.

Some master plates for such operations are illustrated by Fig. 595. The dies for which they are made are used continuously and frequent re-

placement is necessary. The plates give all the center locations for the piercing holes and for the various curves and arcs in the blanking die contour.

The holes in master plates themselves are located originally by the most accurate methods that the tool maker can bring to bear upon the work. The button method is probably the most commonly adopted and if properly followed it will produce results well within the limits of any requirements likely to be demanded of any plate in usual high-grade service. An unusual degree of care is necessary in indicating the buttons and in boring the individual holes in the master plate. They are generally drilled close to boring size, bored to leave a slight scraping reamer cut and then lapped by hand to perfect fit for a plug gage. It will be understood that the plate itself must be as nearly a plane surface as possible before it is put on the face plate. It is usually the case that the tool steel plate is ground and lapped on the faces before boring operations are started.

CHAPTER XIX

MAKING A SET OF SHAVING DIES

The illustrations in this chapter represent the important steps in the construction of a set of shaving dies for a toothed blank $\frac{9}{16}$ in. in diameter by 0.050 in. thick. The blank is made from half hard steel and has nine teeth 0.0887 in. deep. The amount left in blanking for finishing in the shaving dies is 0.003 on a side or a total allowance of 0.006 in.

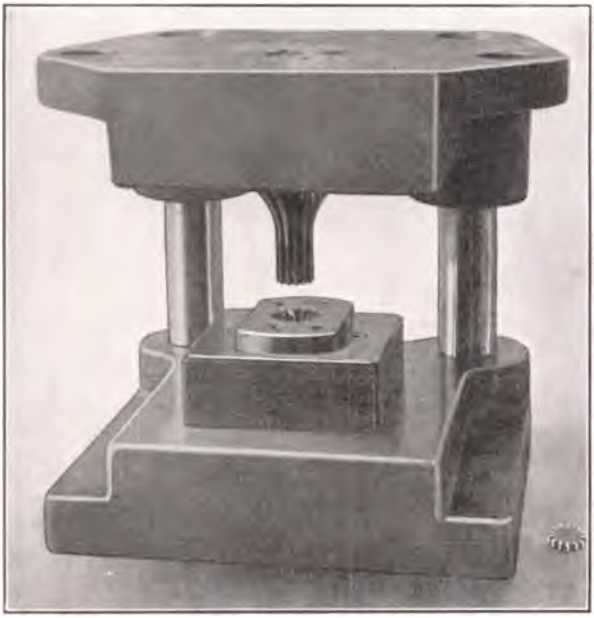


Fig. 596. — The shaving tools

The dies are of the pillar type and are shown in Figs. 596 and 597. All parts are seen in the group photograph, Fig. 598, including even such details as dowels and screws. The die proper is 3 in. square by $1\frac{5}{8}$ in. thick. The die opening is made straight down without clearance for a depth of $\frac{1}{4}$ in., below which it is tapered out for work clearance at an angle of 1 degree on a side. The die can thus be ground down to a depth of $\frac{1}{4}$ in. before its size becomes affected by the clearance angle.

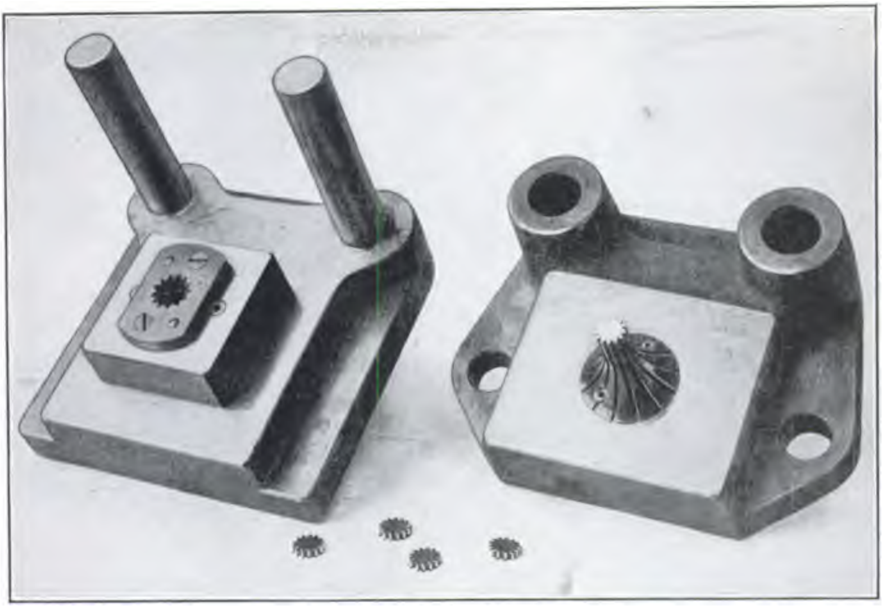


FIG. 597. — Punch head removed from die

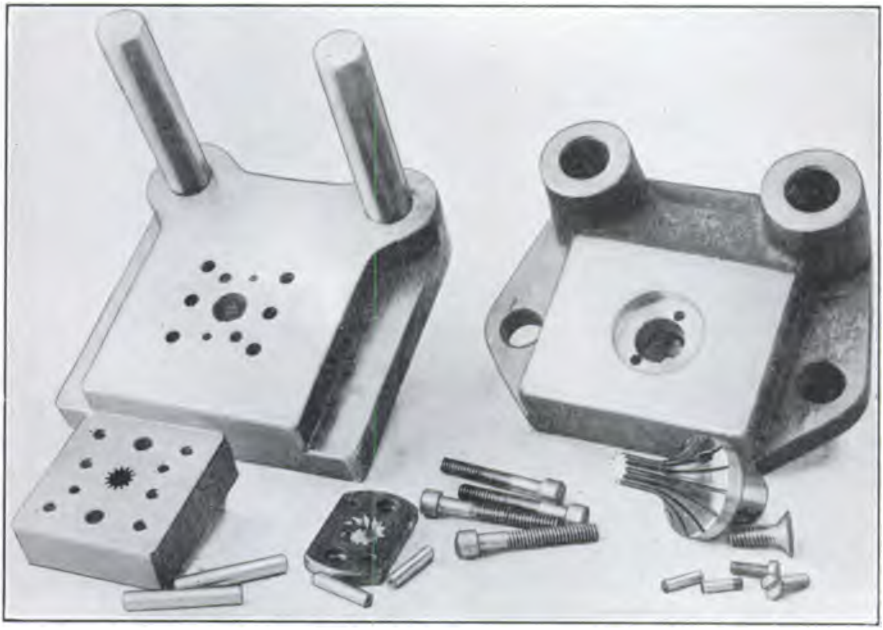


FIG. 598. — Punch and die parts

Working out the Die Opening

There are different ways of getting out the stock from a die opening such as is required here. After the hole is drilled at the center to remove as much material as later operations will justify, the area between the teeth may be drilled out by two or three different sized drills to leave but a narrow wall between drill holes and a close margin between holes and die contour. Or, if the die opening roughed out is sufficiently large in diameter, a slotting tool may be applied to the work with the die indexed in the dividing head of the miller and the rough form of the teeth outlined by the shape of the slotting cutter. In any event enough stock must be left to assure the toothed contour being finished to exact requirements, and with a small

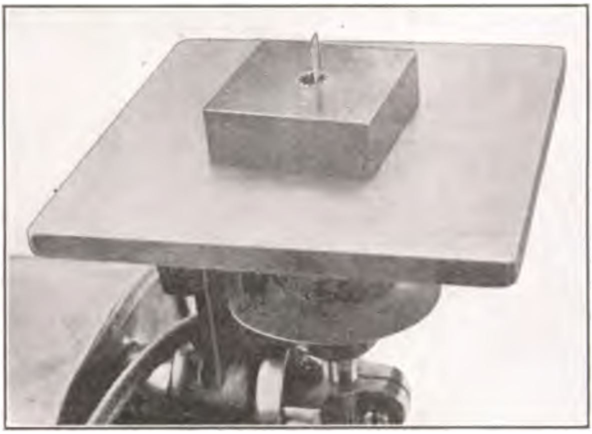


Fig. 599. — The die on the bench filing machine

toothed die like this the hand file and bench filing machine are relied upon to a large extent to assist in getting the tooth form roughed down and then with a combination of file and broach the opening is finished.

The die is shown on the filing machine in Fig. 599. The half tone, Fig. 600, shows the broaches used in working the die to shape. There are two of these broaches, both shown to the right of the die. The punch, unfinished, is seen at the left-hand side with the roughed out nest in front. The formed milling cutters at the right are the ones used for milling the broach teeth.

The sizes of the broaches differ but a few thousandths for only a slight amount of stock is removed by each broach. Even this is taken out piece meal; that is the broach is forced into the die opening say $\frac{1}{64}$ in. deep, then removed and the filing machine resorted to to work out the depth of the die toward the minute shoulder left by the cutting end of the broach. Then the broach is forced in again, this time another sixty-fourth and the filing

process repeated. After the first broach has been passed through the die by repeated stages, aided by the working out of the superfluous metal by the file, the second broach, a couple of thousandths larger, is started through in similar fashion. The operation of forcing the broach into the die under a

FIG. 600. — The punch, the die, the broaches and lap

hand screw press is represented by Fig. 601. For the purpose the broach is mounted in a punch head as seen here, and the die is placed upon the

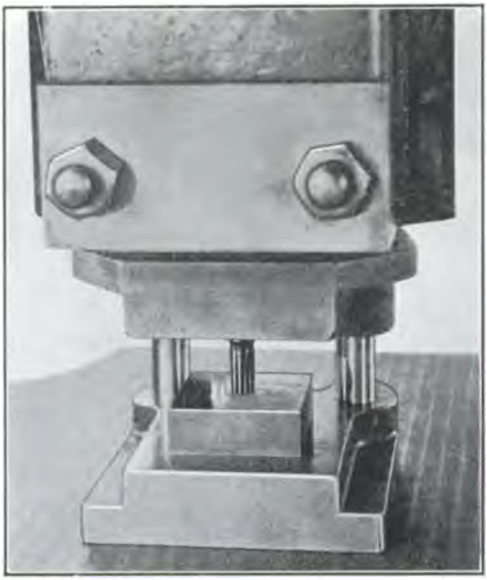


FIG. 601. — Method of broaching out the die

base of a pillar set. The tools are thus properly alined and the passing through of the broach is merely a case of alternating between the operations of forcing the broach in the slight distance referred to at each step and filing out to correspond to the advance of the broaching process.

The straight shank tool at the side of the broaches in Fig. 601 is a lap which is used at a later stage in the finishing of the die. That is, after the die has been sized by means of the broaches and filed for the slight clearance below the straight portion which is $\frac{1}{4}$ in. deep, the die is drilled and tapped in the four corners for four $\frac{5}{16}$-in. fillister head screws for holding it to the die base and also drilled for two $\frac{5}{16}$-in. dowels; it is further drilled for the screws and dowels for holding the nest and then it is hardened and is ready for lapping as in Fig. 602.

The lapping is done under a sensitive drill spindle, with the lap held in the drill chuck as illustrated. Fine emery and oil being applied to the teeth milled along the lap surface, the spindle, while standing without rotation,

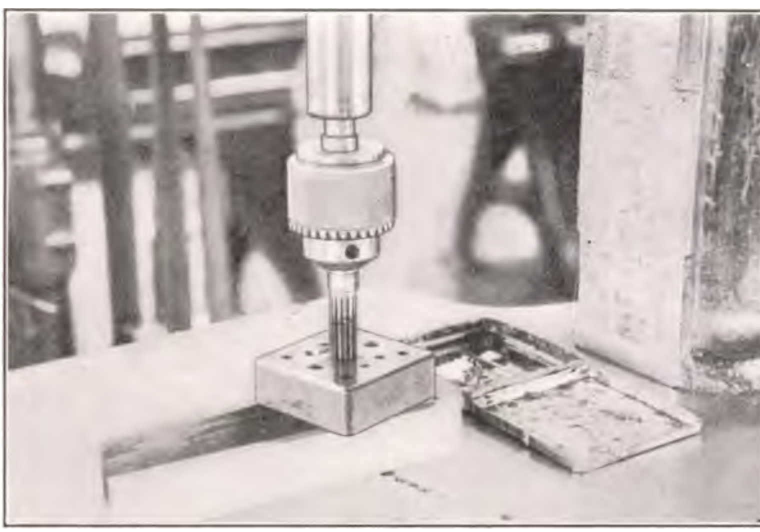


Fig. 602. — Lapping the die opening

is moved up and down by the operating lever to lap out the entire toothed opening in the die and bring it dead to size with all points in the working opening perfectly smooth and the working depth of the die perfectly straight.

Operations on the Punch

The punch is turned up in the bench lathe from a length of tool steel. It is left with a large body which is swept out in a liberal curve to the working diameter of the punch which is left straight for a length of 1 in. The diameter of the body is about $1\frac{1}{4}$ in. and back of the enlarged portion is a hub or extension which is $\frac{3}{4}$ in. diameter. This hub and the body or enlarged shoulder are left a little over size but are afterward finished to fit closely in recessed seats bored out in the face of the punch holder or head

as shown in the detail engraving, Fig. 598. The outer end of the punch, that is, the working end, is left $\frac{1}{4}$ in. long (Fig. 600) and is turned down to a size equal to the diameter of the roots of the teeth so that it may serve as a pilot in a later operation where it is sized by being passed into the die.

The punch teeth are then milled as in Fig. 603, with the work held on the dividing head centers of the milling machine. The formed gear cutters for this operation are seen at the extreme right in Fig. 600. The teeth are cut with great care to produce smooth results and accuracy of size and tooth forms. The punch is then secured in a holder and sheared into the die

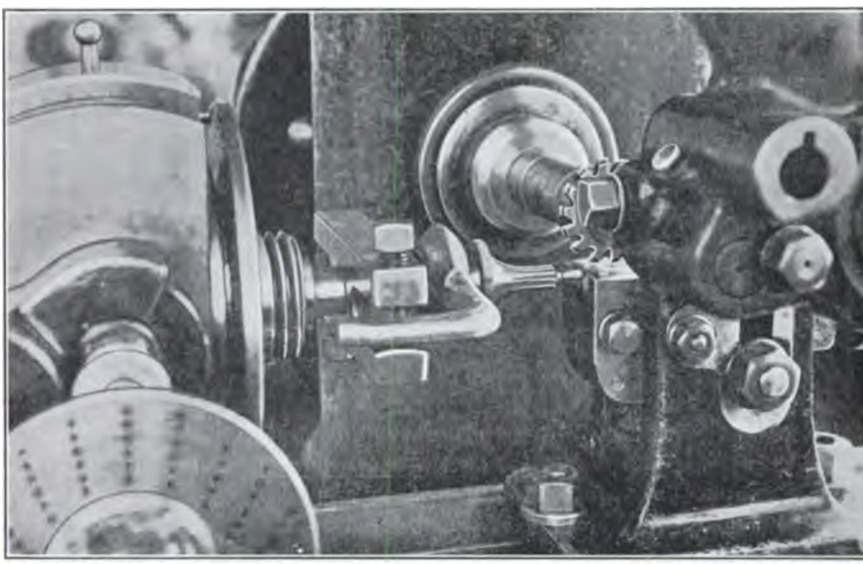


FIG. 603. — Milling the punch

with the projecting pilot acting as a guide. The tools are set up for this operation as in Fig. 604 which illustrates the method of clamping the die on its base after the punch head has been slid down to enter the punch pilot into the die opening. With the tools thus arranged, they are transferred to the hand-screw press and the punch sheared in as explained.

The pilot of the punch is now cut off by setting up the punch in the bench lathe and the holes are drilled in its flange or shoulder for two fillister head screws and two dowels. The screw holes are tapped and the punch is then hardened. After this it is placed in the bench lathe for the grinding of the shoulder and shank. This shank or hub when first turned is left a few thousandths over size and to finish it to dimensions the punch is placed in a bushing in the chuck which is bored out to receive the cutting end of the punch. While held in the bushing in this manner, the punch is tested for running truth of the hub by an indicator placed as in Fig. 605 and

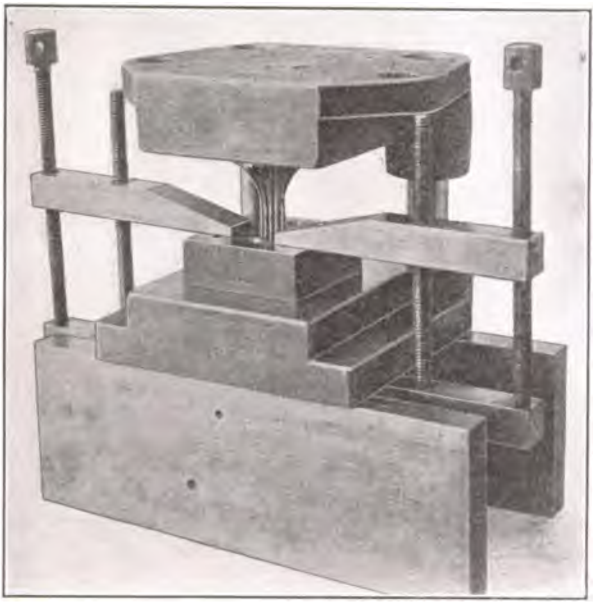


Fig. 604. — Clamping the die in line with the punch for drilling holes in base

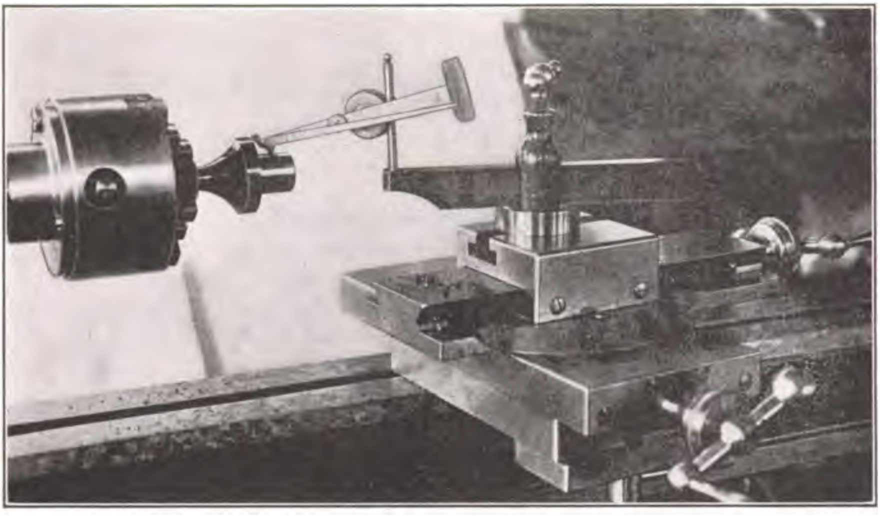


Fig. 605. — Indicating the punch in the bench lathe

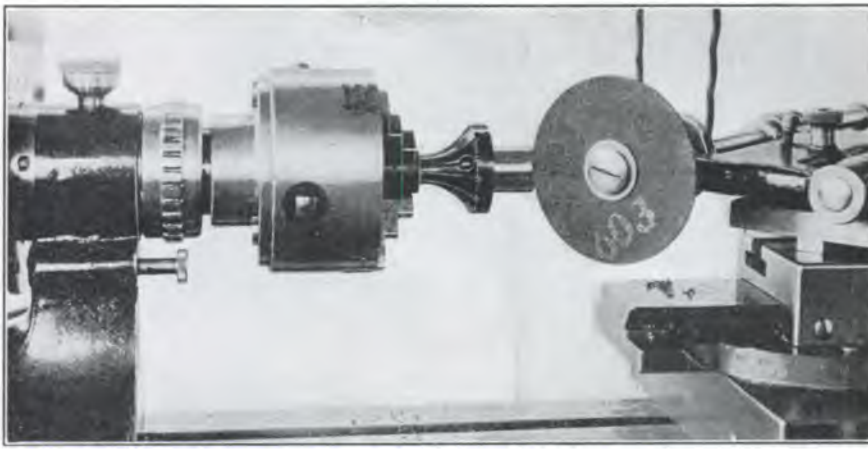


FIG. 606. — Grinding the punch shank

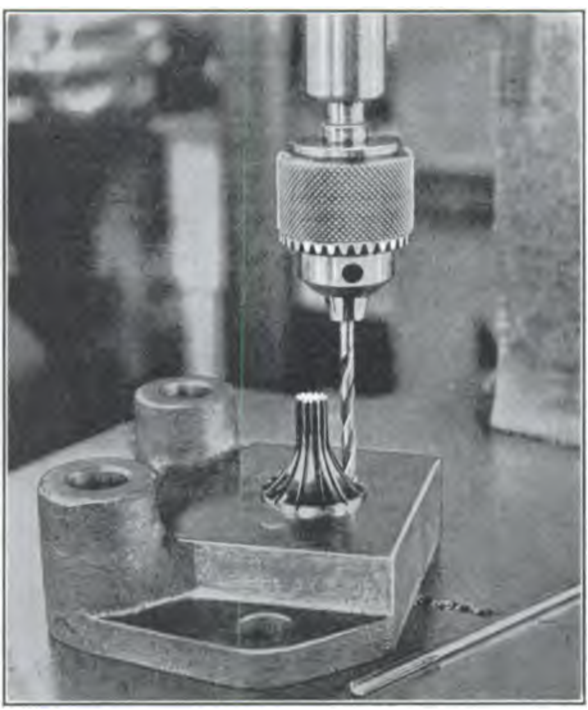


FIG. 607. — Drilling the punch holder for screws and dowels

then ground to diameter by a wheel on the traverse spindle grinder, Fig. 606. The punch can now be seated in its holder or head as in Fig. 607 and used as a jig for the drilling of the holder for the screw holes and the holes for the dowel pins.

Up to this point the die has not been secured to its base or shoe. The operation of locating it in line with the punch for the drilling of the screw and dowel holes in the base is accomplished as shown again by Fig. 604. The punch head is placed over the guide posts or pillars in the die base and the punch entered into the loose die proper to aline it properly with the punch. The clamps are applied as shown to hold the die temporarily for the drilling operation and the punch head slipped up and off the guide pins. This leaves the die clear for the drilling of the four screw holes and two dowel pin holes in the base. Following the drilling, the clamps are removed, the screws and dowels are placed in position and the die is thus fixed in position on its base.

Fig. 608. — The nest and the hand tool

Making the Nest

The nest is originally a round disk of steel faced down to $\frac{1}{4}$ in. thick and drilled through the center to a size suitable for filing and broaching out to the shape and dimensions of the toothed blank which it will be required to hold on the die when in service. A hand broach is used on this thin nest in addition to the regular broaches already described. This broach is shown at the side of the stripper blank in Fig. 608. It is used in conjunction with the filing process and in connection with the blanking punch which is made use of as in Fig. 609 for sizing the nest opening. The nest is in fact set up in the regular blanking dies for the toothed wheel which it is designed to hold, and the blanking punch is applied as a broach to assist in the working of the opening to desired size and form. With the punch entered slightly, say to $\frac{1}{64}$ in. depth, a guide mark is formed in the nest for enabling the opening to be scraped and worked out by means of the file and by the hand tool in Fig. 608.

After the nest opening is sized properly, the bottom side is recessed and the top is countersunk or chamfered to leave a beveled surface for easy placing of the work in the nest. The clearance underside is cut in sufficiently to leave an actual full size nesting opening about two-thirds as deep as the thickness of the stock. The recessed portion at the bottom forms a clearance space for chips.

When the nest opening has been completed, the sides of the disk are milled away to leave a form similar to that shown in Fig. 597 and the holes are drilled for screws and dowel pins. This is done in alinement with the die holes by using the die as a jig.

FIG. 609. — Broaching out the nest

FINISHING DOWEL PINS

A word may be added here in regard to the finishing of the various dowel pins used in these tools. The practice in the shop making these dies is to take a length of steel slightly larger than the required size of dowel and long enough for two pins to be made from one piece. The stock is turned on centers to say 0.008 in. above size and then necked in the middle to a depth of $\frac{1}{16}$ in., then it is hardened. After this it is placed on dead centers in the grinding machine as shown by Fig. 610 and the diameter ground to size. The work is ground from one end to the clearance cut at the middle and then reversed on centers and ground from the other end. Following

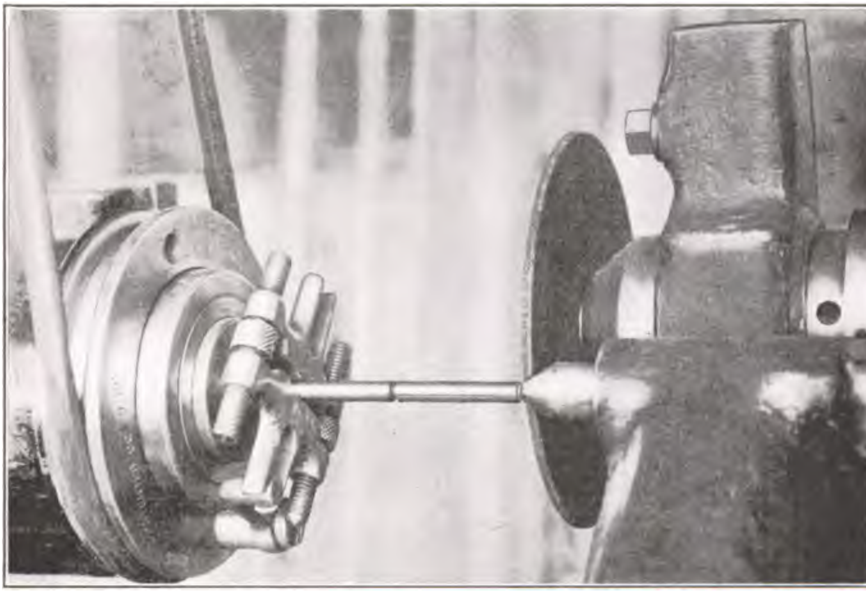


Fig. 610. — Grinding dowel pins

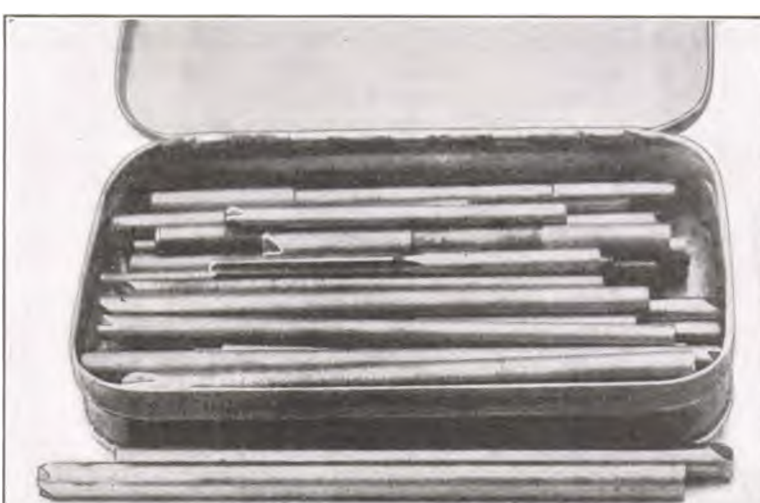


Fig. 611. — A set of reamers

the sizing with the wheel, the pins are separated by breaking them apart at the necked dividing line.

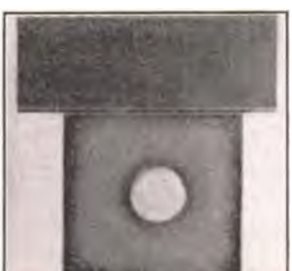
These dowel pins are ground perfectly straight from end to end and it is therefore necessary that the holes in die parts be reamed out true and straight. A convenient set of reamers for the purpose is shown in Fig. 611. These are of all standard sizes required for general die construction. They are of the rose type to cut near the end only and are used after the hole is spotted and drilled through with a slightly smaller drill, to remove a very small amount of metal and leave the hole a proper fit for the pins which are ground closely to standard dimensions.

CHAPTER XX

SOME HARDENING PRINCIPLES APPLIED TO DIES

After every effort has been expended by the die maker in the production of an accurate set of dies, his labor may all prove wasted because of improper treatment of the work in the hardening process. There is probably less definite information available upon this general subject of hardening, than on any other branch of the work. There are also more cases of die failure traceable to improper hardening than to any other cause.

A well-known authority on this subject, Edward Dean, has set down certain principles in connection with the finishing and hardening of high carbon steel dies that should prove of benefit to every one engaged in this line of work. The conclusions drawn have been based upon twenty years of research work in this direction, during which time a large number of observations were made enabling the investigator to form certain definite opinions as to the action of dies in the hardening process and conclusions as to the reasons for various failures when certain tools were placed in service.



Figs. 612–613. — Section of specimens of hardened die steel showing layers of different hardness

All of the work referred to here was done on commercial die steels from 96 to 110 point carbon. All dies referred to were heated for hardening in a gas fired furnace and quenched in clear water at about 85° F.

As this authority points out, we are apt to think that a piece of tool steel hardens all through. It is of course true that a piece of hardened high carbon tool steel is harder throughout after hardening than when it was soft. It is equally true that such a piece of steel having a section thicker than say $\frac{1}{4}$ in. has several different degrees of hardness. In a manner it resembles a piece of hardened carbonized soft steel in that it has a very hard shell and gradually grows softer as the core is approached, although the differences in hardness between the various layers are much less than in the case of the hardened carbonized low carbon steel.

As an illustration it is pointed out that if a piece of high carbon tool steel, say $\frac{3}{8}$ in. thick, 1 in. wide and 2 in. long, is hardened, it will be found to have a soft core surrounded by a harder shell as indicated by Fig. 612.

The difference in hardness between the two areas is some 3 to 5 points on the scleroscope scale, the actual readings running from 92 to 96 for the shell and from 89 to 93 for the core. The specimen illustrated was prepared from a piece of 98-point carbon steel heated to 1410° F., quenched until cold in water at 85° F., drawn in oil to a temperature of 440° F., and then ground away $\frac{1}{4}$ in. on one edge. This ground surface was then polished with several grits of successively increasing fineness, the last one used being Turkish rouge. After the final polishing the surface was etched for about 40 seconds with a 7 per cent solution of iodine. After careful washing in alcohol it was allowed to remain in the air for a few seconds until oxidation commenced. It was then at once coated with white vaseline as a preservative. This method of preparing and keeping the steel specimens for microscopic study is one that was regularly followed in these investigations. The 7 per cent solution of iodine can be bought at any drug store. The white vaseline is found a better preservative than any of the oils, for the reason that it is free from acid.

Fig. 613 illustrates a block of steel 1 in. square treated in the same manner as the piece in the preceding view. The difference in hardness of the two areas on the scleroscope scale is about 3 to 5 points.

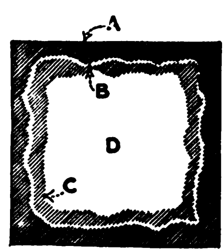


FIG. 614. — Areas of different hardness in die steel

To show more clearly the relationship between the subdivisions of the shell and core, Fig. 614 is presented. This diagram is typical of the polished and etched surfaces of the specimen in Fig. 613.

In Fig. 614 the hard outer shell is indicated by the dark border *A*. Directly inside this is a white line *B*. Inside of *B* is a faint shadowy border *C* of about the same width as *A*. And inside of border *C* is the soft center *D*.

In considering the structure of a die with an attempt to state the results that will come from using a die having these various areas of hardness, the following outline seems to be true: The best service will come from the hard border *A* of Fig. 614. This, in a properly hardened piece, is about $\frac{1}{16}$ in. wide up to the line *B*. Beginning with the line *B* and running inward toward the center *D*, the structure is such that grooving or rapid wear may take place if a part of the die having this structure is used as a cutting edge. In some unsuccessful dies the white line *B* has been found as close as 0.010 in. from the cutting edge and it has even run clear to the edge. It is evident that such a die was either improperly designed or improperly made and hardened to give maximum results.

To further illustrate this point the authority quoted refers to a die shown in Fig. 615 which exhibits all the lines of the specimen in Fig. 613 except that the white line corresponding to the border *B* of the

diagram, Fig. 614, is broken and the center color runs clear through the hard border to the cutting edge. When on test in the press, this die ran only 1 hour at a cutting speed of 480 strokes per minute when it became dull and grooved at the points where the center color ran out to the edge.

The history of this die was investigated and it was found to have been improperly hardened, having been dipped with the grooved face down instead of vertical and moved rapidly with an up and down motion. This allowed steam and vacuum pockets to form in the groove, preventing the cooling water from reaching the surface, creating the soft spot that later scored when the die was placed in service.

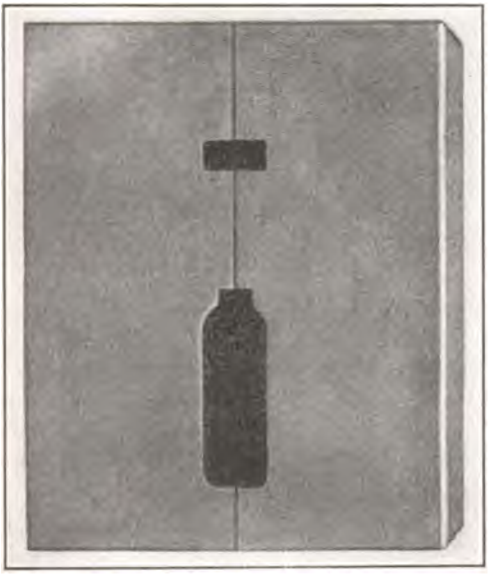


Fig. 615. — Notching die, showing hardness lines on surface

A duplicate of this die made from the same steel at the same time and hardened the same way also ran only 1 hour under test. It was then removed, annealed, refaced, and properly hardened. The hardening this time consisted in dipping it with the grooved face vertical and moving it in such a way and at such a rate that neither steam nor vacuum pockets could form in contact with the surfaces that later on were to form cutting edges. This die was then put to test and ran for 11 hours at a speed of 480 strokes per minute. The first die cut only some 20,000 holes before grooving and dulling. The second die cut about 220,000 holes before dulling. These records show two things. First, the possibility of greatly increasing the service of dies if they are properly made, and second, the importance of obtaining the hard outer shell of hardened high carbon tool steel on all surfaces that are to furnish cutting edges.

Die Hardness Affected by Proportion

After the tests noted above, search was made to discover other conditions that might produce soft areas in the surfaces that must supply the cutting edge. This resulted in bringing out two factors that have a decided influence upon the thickness and relationship of the various hardness layers outlined in the diagram, Fig. 614.

One of the troublesome problems was the hardening of small holes and openings in the dies. If dies are to be made to give maximum service, permitting them to be worn down from 1 in. thick at the outset to $\frac{1}{8}$ in. at the end, it is evident that the inside of all of the openings for cutting edges

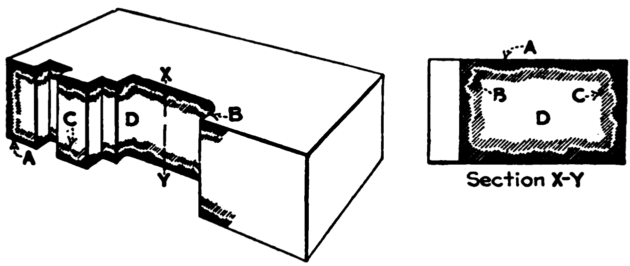


FIG. 616. — Diagrammatic section of a solid die, showing areas and lines of hardness

must be uniformly hard from top to bottom. That this condition did not exist in many dies as ordinarily made has been proved time and again. Often a die would start by giving excellent production records for the first few grindings; then these records would begin to change, giving fewer and fewer blanks per grinding until only one-quarter or even one-tenth as many were being produced as at first. If the die was kept at work, these records would begin to improve after having reached a low point, and perhaps come back to an amount nearly if not quite equal to that produced at first.

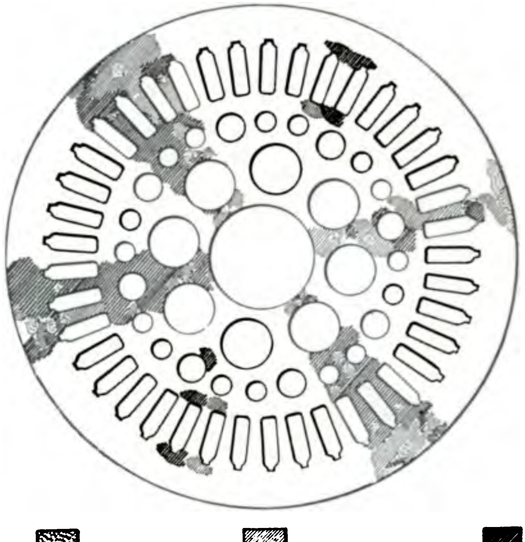


FIG 617. — Difference in hardness over surface of a large hardened die

The conclusion arrived at as to the cause for this is indicated by Fig. 616. The outer surfaces of the die from which the heat could be easily abstracted in quenching possessed the proper thickness of hard shell. But as the middle of the original length of the hole is approached the heat could not be abstracted rapidly enough in cooling and a place is found where the hard shell is comparatively thin and cannot stand up to give maximum service. Actual differences in hardness over the surface of a die are plainly shown by Fig. 617.

From this condition it is concluded that there was too much heat per square inch of surface area in the hole to produce satisfactory hardening. It is probable that the length of time required for the heat to flow out has an important effect upon the thickness and character of the hard layers. Thus in designing dies it is important to proportion them so that an excessive amount of heat will not be compelled to flow through surfaces that later on are to form cutting edges.

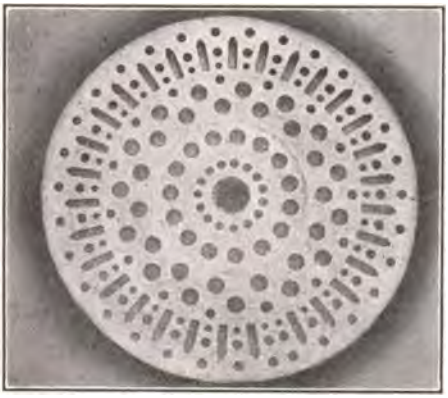


FIG. 618. — Die with proportion holes for hardening properly

This is called, by Mr. Dean, the principle of proportion in die design. In Fig. 618 is a die which, as he points out, has had a number of round holes drilled through it for the purpose of giving proper proportion. In fact all the holes except the slots are for the purpose of obtaining proper proportion to control hardening. These holes are so located as to bring only a comparatively small mass of solid metal around each working slot and so that the heat from every section around a working hole must be able to flow in at least two directions to quenching surfaces, provided one of these surfaces is that of a working hole or opening.

INFLUENCE OF FINISH ON DIE HARDENING

The second factor which has a very marked influence upon die hardening and upon the thickness and uniformity of the outside hard shell is the surface finish. For a number of years the authority quoted had standardized surface finishes that were required for all dies. Because of the decarbonization and oxidation that take place when heating a die, a thin, almost imperceptible coating of scale forms on the surfaces. The thickness and nature of this scale and the ease or difficulty with which it is cast off when the steel is immersed in water have a decided influence upon the hardness. The ideal condition is one where the scale is very thin, is uniform all over the die, and is cast off as soon as the steel enters the quenching water.

It is easy to make a simple test showing this thin scale. Take a small white porcelain dish, fill it with clear water, heat a piece of steel and then immerse it. The thin scale can be seen to float away from the surface of the steel. Microphotographs magnified to 1200 diameters show openings or fissures through the scale, and also a multitude of tiny cables holding this scale to the surface of the steel. The intervening space was filled with

steam when the shell was hardened, thus preventing the free flow of heat and interfering with the hardening process.

The most detrimental finish to successful hardening seems to be a tearing cut with a fine feed and a dull tool, such as can be produced in the lathe, planer, or shaper. A certain specimen shows scratches made on two faces of a steel block 1 in. square. One side was finished smooth, the other so as to produce steam pockets. The block was hardened at 1410° F. and 0.002 was ground off each face after hardening. Each face was then scratched by a fine needle mounted in a steel ball; this needle was merely drawn across the ground faces without applying any pressure except that of the weight of the ball. The face that was finished with a surface suitable for hardening shows no scoring or scratching from the needle. On the other hand, the scratches on the other surface are very noticeable.

In order to obtain satisfactory commercial results in die hardening, the finish on dies has been standardized to one which is equal to that obtained from a No. 2 Swiss file on a flat surface. There is a difference of about one number between the grades of the imported Swiss files and the American Swiss. The No. 1 American is nearly equal to the No. 2 imported. Each leaves about the same grade of finish on the work.

A flat file will leave a smoother finish than a round or half-round file of the same number and cut. If one looks closely at a half-round file, he will see that it presents a series of small corners to the work instead of a smooth cutting edge. To test the various kinds of finish, take a piece of tool steel ½ in. thick and file it with a No. 2 Pillar file until the surface is straight and smooth. Then take a ¼-in. No. 2 round file and file a half-circle about ⅛ in. deep in the steel. The edge where the half-round groove meets the top flat surface will look like a saw when examined under the microscope. The other straight edges that have been filed will show smooth and even.

A No. 4 half-round file will leave approximately the same finish on a curved surface as a No. 2 flat file will leave on a straight surface. It is important to give a half-round file a slight rotating motion during the forward stroke of filing.

Too high a finish or polish on a die seems to have the effect of repelling the water when the piece is immersed for hardening. The quality of the finish should be neither too coarse nor too fine, though at all times a tool maker should be careful not to confuse smooth finish with flat finish. A piece of steel with a corrugated surface, or one cut with a coarse feed, will harden successfully if the surface of the corrugations or feed marks is smooth; and, in fact, it will present more cooling surface to the water than a flat surface. At the same time, unless such a piece is moved in the water in such a way that the liquid flows lengthwise of the grooves, steam pockets are likely to form and unequal cooling take place.

LIST OF REFERENCES

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